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REPORT OF THE NILE PROJECTS COMMISSION

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Report of the Nile Projects Commission.

LONDON,

August 25th, 1920.

To

H.E. THE PRESIDENT OF THE COUNCIL OF MINISTERS.

EXCELLENCY,

I have the honour to submit herewith the report of the Nile Projects Commission as called for in the Note of the Council of Ministers approved January 10th, 1920.

To enable the Commission to judge the reliability of the data on which it was asked to report it had been arranged that it should make a tour on the Nile and in the Sudan.

Before the departure of the Commission for the Sudan the Ministry of Public Works supplied the members with notes on the projects and the data on which they were based, which were afterwards issued in printed form under the title of " Nile Control " in May, 1920, with a portfolio containing the necessary plans.

On March 2nd the Commission left Cairo for Khartum, stopping to visit on the way Esna Barrage and Aswan Dam, at the latter being shown the operation and method of taking sluice discharges.

The method by which the results of discharge and other observations are recorded and filed were fully explained by the official in charge, and the Commission was given every facility to examine and check records.

Immediately after its arrival in Khartum on March 8th the Commission visited Tamaniat (on the Main Nile, about 40 kilometres north of Khartum) with Sir William Willcocks and representatives of the Egyptian and Sudan Irrigation Departments and a current meter discharge was taken.

Owing to erosion the masonry gauge at Tamaniat had collapsed and the water-level was ascertained by levelling from a bench mark close by. As there was some doubt regarding the accuracy of the bench mark it was checked, at the request of the Commission, by an official of the Survey Department specially deputed for the purpose and found to be correct.

The following day the Commission, accompanied by Sir William Willcocks, inspected the discharge sites at Soba and the Nile gauge at Khartum. The members also inspected and studied the recorded readings of all gauges in the neighbourhood as well as other records in connection with the projects.

On March 11th the Commission left for Sennar, on the Blue Nile, stopping on the way at Taiba and Barakat to visit the cotton plantations of the Sudan Plantations Syndicate. The officials of the syndicate accompanied the Commission and information on all matters was freely given.

Three days were spent in study of the site and foundation of the dam, the working plans and proposed methods of construction, and, on the morning of the 14th, the Commission was present with Sir William Willcocks at a discharge taken at a place about 250 yards upstream of the Sennar gauge, and also inspected the new and old Sennar gauges, some levels being taken at Sir William Willcocks' request.

On March 15th the Commission joined the Sudan Irrigation Service steamer *Kassala* at Kosti, on the White Nile, and at once proceeded to the junction of the White Nile and the Sobat, and travelled as far as time permitted up the latter, then going up the Bahr el Zeraf for about 250 kilometres until further progress was barred by the "sudd." The steamer then traversed Lake No and turned up the Bahr el Ghazal for about 40 kilometres.

It then continued up the Bahr el Gebel to the mouth of the Kit River, a short distance beyond Rejaf, and returned direct to Khartum, stopping only at Gebel Aulia, where the two engineering members inspected the site of the dam and the trial pits and bore holes which had been sunk in the centre line.

After arrival in Khartum informal meetings were held with the officials of the Sudan Government, and, as a result of conversations with them and the Managing Director of the Sudan Plantations Syndicate, a great deal of useful information was obtained which clearly indicated the view held by the Sudan Government on the projects.

During the absence of the Commission from Cairo a notice had been published in the *Official Journal* and in the press, both European and Egyptian, stating that the Commission was prepared to receive criticisms on the projects as published in "Nile Control."

Criticisms were submitted by Sir William Willcocks, Colonel Kennedy, Abdullah Pasha Wahbi and his Committee of Egyptian engineers, and other interested persons. Eleven public meetings were held, beginning on May 25th, to hear the evidence on oath in support of and against the charges made by Sir William Willcocks and Colonel Kennedy. On June 22nd another public meeting was held to hear the criticisms made by the Committee of Egyptian engineers, which was further granted an informal interview on the following day. This was the last evidence taken by the Commission.

An interim report was submitted to the Council of Ministers on June 24th and the Commission then dispersed to reassemble later in London.

I have the honour to be,

Excellency,

Your obedient Servant,

(Signed) J. L. CAPES,

Secretary.

Introductory Note.

In a Note dated January 10th, 1920, the Council of Ministers of the Egyptian Government approved the appointment of a Commission to report on the projects for the control of the Nile put forward by the Ministry of Public Works. In this Note the terms of reference of the Commission were stated as follows :—

“ The Commission is requested to give to the Egyptian Government its opinion on the projects prepared by the Ministry of Public Works with a view to the further regulation of the Nile supply for the benefit of Egypt and the Sudan. In particular the Commission is requested :—

“ (1) To examine and report upon the physical data on which the projects are based.

“ (2) To report upon the propriety of the manner in which, as a result of these projects, the increased supply of available water provided by them will be allocated at each stage of development between Egypt and the Sudan.

“ (3) To advise as to the apportionment of the costs of the proposed works and of this inquiry as between Egypt and the Sudan.”

In a further Note, dated February 24th, the Commission was empowered, if it thought necessary, to add to itself a judicial member for the purpose of conducting the inquiry if evidence had to be taken on oath. As it was clear, from the nature of the criticisms submitted by Sir William Willcocks and Colonel Kennedy, that evidence would have to be so taken a judge was appointed by a decree dated March 24th, 1920.

An interim report was submitted to the President of the Council of Ministers on June 24th, 1920. In this the Commission stated :—

“ After careful consideration of all the evidence we are of opinion that there has been no falsification or intentional suppression of records nor any fraudulent manipulation of data or gauges by Sir Murdoch MacDonald or by any one else.

“ We have studied the projects as described in ‘ Nile Control ’ and have considered the criticisms of these which have been submitted, and we recommend that, considered from a strictly engineering point of view, the White Nile Dam, the Gezira Irrigation Scheme, and the Blue Nile (Sennar) Dam, and the Nag Hamadi Barrage should be carried out at once.”

The report is arranged in four chapters and an appendix as follows :—

Chapters I. and II. deal entirely with the charges brought by Sir William Willcocks and Colonel Kennedy in connection with the reliability of the data and are unanimously approved by the Commission.

Chapter III. deals with the projects from an engineering point of view and is unanimously approved by the Commission.

Chapter IV., in two sections, deals partly with criticisms other than those examined in Chapters I. and II., and partly with the future allocation of water. As regards the latter the Commission is not unanimous, Section One being signed by the President and Dr. Simpson and Section Two by Mr. Cory.

The Appendix contains the criticisms on the data as presented in the form of charges by Sir William Willcocks and Colonel Kennedy, and the technical criticisms presented by Abdullah Pasha Wahbi and the Committee of Egyptian engineers.

**Summary of Findings Extracted from Judge Booth's Opinion on the
Evidence taken on Oath.**

COLONEL KENNEDY'S CHARGE No. 1.

“ My conclusion is that the copy of page 2 of the ‘ Blue Nile Memorandum ’ itself, if it stood uncontradicted, would afford no sufficient proof of the true official Sennar gauge readings at the beginning of 1914 ; *à fortiori*, it must be ignored when contradicted by a body of sworn testimony.

“ The mention in Colonel Kennedy's note of the reading 10·10 for the Sennar gauge on January 24th must be taken to be a mistake. The reading he obtained was in reality that of January 31st.”

SIR WILLIAM WILLCOCKS' CHARGE No. 1.

“ I accept without hesitation the evidence of the witnesses called, nor have I any doubt that the books and documents proved by them contained the readings of the Sennar gauge as recorded and reported at the material time.

“ In the teeth of the sworn testimony of a number of witnesses, no weight at all can be given to Sir William Willcocks' argument ” (as to the Sennar discharge curve).

COLONEL KENNEDY'S CHARGE No. 5.

“ There was never any thought of showing exaggerated discharges by means of the falsification of gauge readings. The sequence of documents I have quoted, obviously genuine, are, in my opinion, the strongest possible testimony to the good faith of the Department.

“ On the documents put in there is no reason whatever for supposing that Sir Murdoch MacDonald's opinion was not honestly given.”

SIR WILLIAM WILLCOCKS' CHARGE No. 2.

“ The good faith of the explanation of the Public Works Ministry receives strong confirmation from the explanation which Sir Murdoch MacDonald is able to give as to the non-publication of the Inspectors-General's Report for 1912, and also from the fact that it is not suggested that any particular use has ever been made of the erroneous figures, nor has any motive for the non-publication of this particular error been suggested.”

Summary of Findings Extracted from Chapter II. on Reliability of Data.

SIR WILLIAM WILLCOCKS' CHARGE No. 1.

"In the opinion of the Commission the 'bump' on the Sennar gauge curve and the abnormal shape of the discharge curve are both due to the same cause, namely, the alteration in the arrangement of the sandbanks and channels in the river.

"There is no other conclusion to be drawn than that Sir William Willcocks' calculated discharges were absolutely valueless."

CHARGE No. 3.

"The Commissioners are satisfied that there has been absolutely no exaggeration of the discharges—on the contrary they are convinced that there is no other river in the world comparable with the Nile whose discharge is so accurately determined as is that of the Nile during the low stages of 1916."

CHARGE No. 3. APPENDIX "A."

"The Commissioners strongly object to the whole method (employed by Sir William Willcocks) and they are not prepared to admit that any conclusion reached by such a method is worthy of consideration."

CHARGE No. 3. APPENDIX "B."

"The results Sir William Willcocks obtained do not prove falsification or even bad work, they simply prove that the method itself is imperfect."

CHARGE No. 3. APPENDIX "C."

"On the general question of current meters the Commission is satisfied that Egypt is now employing the method which is employed by irrigation engineers all over the world, and a return to measurements by means of floats would be a serious retrograde step."

CHARGE No. 4.

"The Commission has decided that the Sennar gauge was not altered in 1916."

CHARGE No. 5.

"A comparison of the differences between the gauge readings at Khartum, Roseires and Sennar before and after 1914 cannot form the basis of any such discussion as that of Sir William Willcocks. . . . The Public Works Ministry have naturally used the Aswan discharge curve prepared by themselves, not, as suggested by Sir William Willcocks, because it gave higher discharges than those given by his curve, but simply because they naturally put more reliance in a curve which they have themselves prepared from observations made at Aswan than in an old curve based upon observations which they know very little about and made at many different places on the river from Cairo to Aswan."

COLONEL KENNEDY'S CHARGE No. 6.

“ In the absence of any amplification of Colonel Kennedy's charge which would
“ give an idea of the grounds on which he based it, the Commission can do no more
“ than state . . . that they can find no evidence of any falsification or desire to
“ mislead.”

COLONEL KENNEDY'S CHARGE No. 7.

“ Colonel Kennedy knew that Sir Murdoch MacDonald had no original records of
“ the Khartum gauge, the original notebook being in Colonel Kennedy's own charge
“ and Colonel Kennedy had not explained to Sir Murdoch MacDonald how the gauge
“ was in error. It is, therefore, clear that Colonel Kennedy knew quite well that Sir
“ Murdoch MacDonald could not have deliberately published false readings.”

CHAPTER I.

**Report and Opinion of Judge Booth on Matters dealt with at the Public
Sittings for the Hearing of Evidence on Oath.**

THE Commission was given the power to take evidence on oath for the purpose of forming its opinion on the physical data on which it was asked to report. I was appointed a member of the Commission in order to direct the proceedings at the taking of this evidence. The Commission, by public notice, called for objections and criticisms of the data to be put in in writing, and Sir William Willcocks and Colonel Kennedy both lodged criticisms, some of which were in the form of "charges" against Sir Murdoch MacDonald personally. Of these "charges" it was agreed that evidence on oath should be taken on the first six of Sir William Willcocks, and all the seven of Colonel Kennedy. The Commissioners considered that the hearings ought to be public.

Before the public hearings began, the Commissioners made an effort to confine the discussion within the strict wording of their terms of reference, and they suggested that Sir William Willcocks and Colonel Kennedy should put forward their criticisms in a form other than that of charges of fraud and falsification against Sir Murdoch MacDonald. They were unwilling to do so, and as there was no doubt that the charges brought by them were the occasion of the Commission's being given the power to take evidence on oath, the Commissioners did not insist. At the hearings the case was treated, not only by the accusers, but by the defence—as indeed was seen to be inevitable—as the hearing of an accusation of a conspiracy to deceive the public by the falsification and suppression of documents; and it became increasingly clear that the Commissioners would be obliged to express their opinion on the merits of the case looked at from this standpoint. I am doubtful whether it was intended by those who were responsible for the addition of a judge to the Commission, and for my own appointment, that I should take any part in the decision. But the Commissioners all wished that I should express my opinion on the matters dealt with at the public hearings, and the following is written at their request. It is to be understood that wherever an opinion on a technical question is called for, I adopt that of the Technical Commissioners.

Before the public hearings, two informal sittings were held at which procedure was discussed, and a partially successful attempt was made to arrange for the exchange of lists of documents and their inspection by the parties. The Commission drew up a note to serve as a guide to the procedure which it was intended to follow, in which the only point calling for special mention is the decision not to be rigidly bound by the strict rules of the English Law of Evidence.

The public hearings were conducted in an orderly and judicial manner, and although there was some difference between the Commissioners and the defence as to the way in which the hearing of the charges should be taken, neither side was in fact prejudiced in any way by the change of method which was adopted after the partial hearing of the defence to the first charge of Sir William Willcocks and the first three charges of Colonel Kennedy, concerning the Sennar gauge readings. The defence which was eventually put forward on the whole case, in my opinion, justified Mr. Maxwell's holding out against the original intention of the Commissioners to deal with the charges piecemeal.

The accusers, who were not represented by counsel, were able to assist one another, and they received not only a fair, but an indulgent hearing from the Commissioners. It was at one time proposed that issues for trial should be settled by me, but upon consideration it appeared that this course was neither necessary nor desirable. The omission to do this was criticised by Colonel Kennedy, but it was deliberate and occasioned no prejudice whatever to the accusers.

In giving my opinion on the charges I shall devote my principal attention to the first two charges of Sir William Willcocks, which correspond to the first four charges brought by Colonel Kennedy. These are the charges on which the greatest stress was laid, as "criminal charges"; and the first charge of Sir William Willcocks, corresponding to Colonel Kennedy's first three, is the charge to which Sir William Willcocks told us that he referred when he informed Sir Paul Harvey that Mr. Craig had said, after considering the proofs, that Sir William had completely established his charges.

The first charge of Sir William Willcocks accuses Sir Murdoch MacDonald—

- (a) Of altering, or causing to be altered, the Blue Nile gauges (*i.e.*, gauge readings) at Sennar between early in December, 1913, and early in February, 1914.
- (b) Of adding, or causing to be added, a greatly increased discharge to the volume of that river in this interval.
- (c) Of the loss of a public document of prime importance.

The first three charges of Colonel Kennedy accuse Sir Murdoch MacDonald—

- (1) Of falsifying the gauge readings for Sennar for the period 11/1/14 to 20/1/14; true figure (ten-day mean), 10.19; forged figure, 10.28.
- (2) Of falsifying the gauge readings for Sennar for the period 21/1/14 to 31/1/14; true figure (ten-day mean), 10.09; forged figure, 10.17.
- (3) Of falsifying the Sennar gauge reading for 21/1/14 from its correct figure, *viz.*, 10.10, to its present forged figure, *viz.*, 10.20.

The first two of Colonel Kennedy's charges relate to alleged forgeries of the "ten-day mean" figures, and therefore involve the forgery of the individual readings, whilst the third relates to the alleged forgery of a single daily reading. It will be seen that these three charges of Colonel Kennedy are in fact particular instances of the general accusation made by Sir William Willcocks, and they are therefore to be considered together. The figures alleged to be forged are those officially published by the Public Works Department, on the basis of the documents and books produced at the hearing as original records, and particularly the Khartum gauge book, which has special relation to Colonel Kennedy's evidence. They may be found, in the shape of five-day means, in the recently published "Nile Control," on page 182, Vol. I.

These charges are supported by two kinds of evidence, direct and inferential. The direct evidence is contained in two documents:—

- (a) The "Blue Nile Memorandum,"
- (b) A document called "Notes *re* Conditions governing the Lift of Pumps at "proposed pumping station Wad el Nau,"

the latter being supported by Colonel Kennedy's own evidence as to his personal recollection.

The "Blue Nile Memorandum" must be discussed in some detail. It is said to have been forwarded to Colonel Kennedy on February 25th, 1914, by the private secretary to the Governor-General of the Sudan, and the original of the covering letter enclosing "A Memorandum on the Subject of Levels in the Blue Nile Valley" has been produced. This Memorandum, as is now admitted, was prepared by Sir Murdoch MacDonald and forwarded through the Governor-General as the result of a communication to the latter from Colonel Kennedy, then Director of Works in the Sudan Government, who was concerned as to the precise level requisite for the intakes of some pumps which he was erecting at Wad el Nau and as to the

quantity of water in the river available for the Gezira irrigation scheme. The Memorandum consisted of two pages, and a copy of the second page only was produced to the Commission by Colonel Kennedy, who stated that the original had been returned by him to the private secretary a few days after receipt, and after he had taken a copy. Neither the original nor a copy could be produced by the Public Works Department, which indeed at first suggested that there may never have been a "Blue Nile Memorandum." A "White Nile Memorandum" was admittedly forwarded and received by Colonel Kennedy at about the same date, and a copy of it was put before the Commission, together with the copy of the covering letter, said to belong to it, dated February 18th, 1914, from Sir Murdoch MacDonald to Sir Reginald Wingate, which spoke of "A short Memorandum on the Maximum Level likely to occur in the Blue Nile valley," it being contended that the word "Blue" was written in mistake for "White." But it was subsequently admitted by counsel for the Public Works Department that the sheet put in by Colonel Kennedy must be taken to be a copy of part of a document referring to the Blue Nile, which really did emanate from Sir Murdoch MacDonald at the time in question. Colonel Kennedy tendered his part-copy as secondary evidence of a document, the original of which he had called for from the other side; Mr. Maxwell, representing the Public Works Department, objected on the ground that if a document is tendered in evidence the whole of it must be put in. I am not sure that he was right on the point of law; there is a great difference between putting in an original document as part of one's case and giving secondary evidence of a document of which the original is alleged to be, or to have last been heard of, in the possession or control of the adversary. It is questionable, I think, whether any sort of secondary evidence can be shut out under these circumstances on the ground of incompleteness, even if wilful; but, on the other hand, all such evidence is admitted for what it is worth, and subject to comment. The Commission had already laid down that they would not necessarily hold themselves bound by the strict rules observed in English courts, so that it was not necessary to rule on the point of law; and the part-copy tendered was admitted for what it was worth, Colonel Kennedy swearing that the missing page, the contents of which he refused to reveal, contained nothing material to the present charges, and that he had no copy of it in Egypt.

The part-copy so admitted begins in the middle of a sentence, and so far as material runs as follows:—

"10-19, 10-09 and 10-06 respectively—(ten-day means, 1st Dec., 1913, to 10th Feb., 1914). But it is to be remembered that, though these Sennar gauge readings are low in comparison with previous years, the factor of erosion of the river bed must be allowed for. . . . Taking the erosion into account, the gauge reading 10-06, which Captain Kennedy mentions as being within 10 cm. of the extreme L.S.L. recorded at Sennar—"

The page is dated at the foot "19/2/14," and signed "M. MacDonald."

Colonel Kennedy contends that this document proves that the figures therein mentioned represent the last three ten-day means, up to February 10th, 1914, or the Sennar gauge readings as officially recorded daily at the time. Now it was sworn to by the Public Works witnesses that the Sennar gauge readings were reported to Khartum and Cairo by means of postcards containing a week's readings on a card, and on the evidence as to the dates of posting it is impossible that Sir Murdoch MacDonald should have obtained by post at the date of the Memorandum the materials necessary for arriving at the last of the ten-day means quoted. The Public Works Department also called a number of witnesses, whose evidence will be discussed later on, to prove directly that the figures as published represent the genuine original observations officially made. To meet the difficulty as to the post Colonel Kennedy suggested the possibility of the readings having been telegraphed to Cairo. Now it happens that the Public Works Department amongst their evidence produced some cards called "Nile Gauge Readings," sworn to as having been printed in 1914, upon which it is recorded that the readings of certain gauges, including Roseires, but not including Sennar, were telegraphed. Is it possible that Sir Murdoch MacDonald, for the purpose of information required, deduced the Sennar readings from the telegraphed Roseires readings? Is it possible, again, that he got them from Colonel Kennedy himself, who had evidently mentioned the particular reading 10-06, which is not

one of the daily readings in the official record? Again, he, or the person who gave him the figures, may have simply made a mistake. It is unfortunate and, in my opinion, extraordinary that Sir Murdoch MacDonald was asked no question about it at the public hearings, so that we have no explanation from him on oath, but I am told that he had previously told the Commissioners that he had no recollection of the document whatever. It is difficult to resist the suspicion that the first page of Colonel Kennedy's copy of the Memorandum, which he told us was torn, but only to the extent of lacking four figures at the foot, may contain some clue to the origin of the mysterious ten-day means. What it may fairly be assumed that it does not contain is a statement that they are obtained from the officially recorded Sennar readings. If there were anything of the sort, it would either have been produced or we should have been told that it was there. Colonel Kennedy gives as his reason for not producing the first page of his copy, either here or before the London Committee, that he is "not putting all his cards on the table." Whatever may be thought of this, it cannot relieve Colonel Kennedy, so far as the present opinion is concerned, from the consequences of having put forward his evidence in a way which gives the Commissioners no opportunity of forming their own opinion of the whole of the document. My conclusion is that the copy of page 2 of the "Blue Nile Memorandum," if it stood uncontradicted, would afford no sufficient proof of the true official Sennar gauge readings at the beginning of 1914; *a fortiori* must it be ignored when contradicted by a body of sworn testimony.

The other piece of direct evidence produced by Sir William Willcocks and Colonel Kennedy is the "Notes *re* Conditions governing the Lift of Pumps, etc.," previously mentioned. It contains the following footnote:—

"Note.—Figures obtained from Sudan Irrigation Department on 4/2/14:—

"Sennar gauge reading on 24/1/14 . . . 10·10 m.

"Wad Medani gauge reading on 31/1/14 . . . 9·73 m.

"Khartum, 4th Feb., 1914."

The date at the foot was declared by Colonel Kennedy to be in the handwriting of his then secretary, Mr. Hollis, who had "conveniently disappeared" from the service of the Sudan Government. The statement made by Colonel Kennedy in cross-examination by Mr. Wasey Sterry does not permit any weight to be attached to the innuendo.

Colonel Kennedy further stated in evidence that the readings mentioned in the note were obtained by his engineer or secretary, he could not remember which; that they were checked by himself at the Sudan Irrigation Office, and that subsequently they appeared in the form of this note in the files. Colonel Kennedy's statement as to his having personally checked the figures was made in a form which makes it difficult to feel sure that he really remembers having checked these particular readings. What he said was (p. 13), "The levels given were as obtained by my engineer or by my secretary, I cannot state definitely which—but what I can state perfectly definitely is that they were checked by me most minutely and that I actually went several times to the Sudan Irrigation Service Office at Khartum, checked the levels, checked the gauge book or gauge cards—I cannot quite remember—and afterwards they appear in the form of this note which is in the file." Now the footnote itself states that the figures were obtained on 4/2/14, and the footnote itself is dated "Khartum, 4th Feb., 1914." Did Colonel Kennedy go several times to the Irrigation Office on that particular day to check minutely these two gauge readings? It is six years ago, and I am inclined to think that Colonel Kennedy's recollection is, in reality, a general recollection of having gone several times to check gauge readings rather than a precise recollection of having checked the particular two readings in question. Against this an original letter was put in purporting to be signed by Mr. L. Landon, then in charge of the Sudan Irrigation Office at Khartum, and sworn to by Mr. Burnett, the present Sudan Director of Works and successor of Colonel Kennedy in that office, as having been found in 1919 in the Barakat file, in which Colonel Kennedy's note also was filed. It was proved that Mr. Landon had left the Sudan in May, 1919, and his present whereabouts appears to be unknown.

This letter runs as follows :—

“ KHARTUM, *Feb. 4th*, 1914.

“ DEAR KENNEDY,—To confirm our conversation on the telephone, in case of possible error, the following are the gauge readings I gave you :—

“ Wad Medani, 31 Jan., 1914	.	.	.	.	9.73
“ Sennar	.	.	.	.	10.10

“ Yours sincerely,

(Signed) “ L. LANDON.”

It will be seen that the two figures are the same as in Colonel Kennedy's “ note,” but the Sennar reading of 10.10, instead of being the reading for January 24th, appears here as the reading for January 31st, and this coincides with the officially published figures for that date, whereas the officially published, and alleged forged, reading for January 24th was 10.20. It is only necessary to assume that a clerical error was made in copying the date in Colonel Kennedy's note in order completely to explain the discrepancy. Colonel Kennedy was, of course, obliged to suggest that this letter was a forgery, but there is no reason for rejecting Mr. Burnett's evidence as to its provenance and genuineness, and Colonel Kennedy in cross-examination would not go further than to say that he did not know whether the signature was Mr. Landon's, after having stated that he thought he would know Landon's signature if he saw it. It was suggested that the letter ought to have been found and produced when Colonel Kennedy put forward his charge in 1918, but Mr. Burnett said that he did not treat Colonel Kennedy's letters seriously, and had taken no action, and he stated definitely that he had not then turned up the file in question to look for evidence. Colonel Kennedy further admitted that for the purpose for which he required the readings he would want to get the Sennar and Wad Medani levels, for the same day if possible. I must add that no copy of Mr. Landon's letter, which was typewritten, is to be found in the Sudan Irrigation Office, but it is a private or semi-private letter, and the absence of a copy cannot, in my opinion, outweigh the evidence of Mr. Burnett, which is supported by the positive evidence of the Public Works Department as to the true recorded reading for January 24th. I think that the Landon letter of February 4th, 1914, must be accepted as genuine, and the result is that the mention in Colonel Kennedy's note of the reading 10.10 for the Sennar gauge on January 24th must be taken to be a mistake. The reading he obtained was in reality that of January 31st.

What I have called inferential evidence in support of these charges takes the form, primarily, of an argument based on a comparison of the Sennar gauge readings with the recorded Roseires gauge readings elaborated with a diagram prepared by Sir William Willcocks.

Sir William Willcocks says, in effect, that the readings of the Sennar gauge in a winter following a low flood ought to follow the readings of the Roseires gauge, which is 291 kilometres higher up the river, fairly regularly ; so that curves plotted on a diagram from a series of daily readings of the two gauges should follow similar courses, and the Sennar curve should not show deflections which are not substantially the reproduction of similar deflections in the Roseires curve. For the purposes of the present charge Sir William has prepared a diagram on which the curves are plotted from the officially published figures for the two gauges, the two curves being so placed relatively to one another that the Sennar curve, after keeping during November well below the Roseires curve, begins early in December to rise relatively to the Roseires curve, crosses it about the middle of the month, and remains above the Roseires curve until the beginning of February, when it returns to a position which Sir William accepts as normal. Sir William adds to his diagram a curve showing what, in his opinion, the Sennar readings ought to have been during the period in question, and calls these “ Actual Sennar Gauges,” adding the word “ approximate ” for the part where he is not supported, as he alleges, by the “ Blue Nile Memorandum ” ten-day means. This want of uniform correspondence between Roseires and Sennar readings, if it represents the reality, must have been caused by changes in the river bed between the two places, or, more probably, a short distance below Sennar. Its occurrence is not an impossibility—so much, I think, was admitted by Sir William himself—and at other times of year, or after a high flood with much silt in the river, it might not even cause remark. What Sir William says is, that from his knowledge of the bed of

the Blue Nile at Sennar, and the way it has behaved on similar occasions in the past, he is able to assert positively that the thing could not happen. "All low years," says he, "are practically normal at Sennar." The exact weight of Sir William's opinion and argument must be assessed by those having technical knowledge. The Technical Commissioners tell me that, in the case of a river like the Blue Nile, and even under the conditions insisted on by Sir William, it cannot be assumed that changes sufficient to account for the discrepancy may not have occurred; indeed, I gather that they would not consider them very surprising. It is certainly remarkable to the uninstructed mind that there should be just this one place, and one condition of the river, in respect of which Sir William is ready to press the argument to this length; for when similar abnormalities were put to him in cross-examination, he would not admit that it would hold good of any other place on the Nile. It is fair to add that, in cross-examination, Sir William pointed out that on the top of this argument he had the recorded gauges, meaning the direct evidence which has been already discussed.

It seems to me that Sir William's test might be a reasonable one to apply to readings suspected of inaccuracy, with a view to further inquiry; it is quite another matter to assert that readings which do not conform to it must necessarily be false.

Against the case so made by the accusers, the Public Works Department brought forward a quantity of direct evidence to show that the published figures for the Sennar gauge readings December, 1913, to end of February, 1914, were in fact the figures observed and recorded at the time. It was proved that, according to the ordinary usage, the gauge reader at Sennar would be supplied with a book containing a counter-foil and three detachable postcards, each containing space for seven days' readings. The daily readings would be recorded on the counterfoil, and at the end of each week the three postcards would be filled in and posted, one to the Head Station of the district (in this case Wad Medani), one to the Khartum Irrigation Office, and one to the Survey Department (now the Physical Department of the Public Works Ministry) at Cairo. At each of these places were kept books or cards on which the readings from the postcards were entered up on arrival, and the postcards initialled by the recording clerk. In Cairo the postcards passed through three hands, all of whom initialled them, and the gauge readings were recorded, firstly, on cards showing the daily readings of an individual gauge for a whole year; secondly, on another series of cards showing readings of several gauges for a month; and thirdly, by the rainfall recorder. There were produced, and sworn to by the men who had made some or all of the entries during the material period—

- (a) The Wad Medani gauge book.
- (b) The Khartum gauge book in duplicate.
- (c) From Cairo, the original postcards received from Sennar, initialled by three persons, all of whom were called and swore to their initials, and the gauge cards containing a year's readings sworn to by the man who had prepared them.

There were also produced from Cairo some printed cards headed "Nile Gauge Readings," each showing the readings of a certain number of Nile gauges over short periods, and some proof sheets for a book called "Rains of the Nile Basin and Nile Flood, 1913." With regard to the "Nile Gauge Readings" cards, an English official, head of the printing office of the Survey Department, swore that they had been printed under his direction in the year 1914 and at the dates mentioned on them, that is to say, within a fortnight or so of the dates of the readings recorded on each card. The "Rains of the Nile Basin and Nile Flood, 1913," proofs were sworn to by an English official of the Government Press as having been pulled in 1915, when the type was set up, though the book was not published then owing to shortage of paper, many other documents having been held up on the same instructions. All these documents showed all or some of the figures for Sennar which are alleged to have been forged. The original postcards which had been sent to Wad Medani were not produced, and the evidence with regard to them was that they had been tied in bundles and put in a drawer by the man who entered up the gauge book, but he was unable to say what happened to them afterwards. The Wad Medani office was closed in May or June, 1914. The original Khartum postcards were destroyed, according to the evidence, by the man who entered up the gauge book about a year after their receipt, and in accordance with what was said to be a general rule in the Sudan offices. The Cairo postcards were preserved in the library of the Department, from which they had been obtained by one of the witnesses

who was called. These postcards were, according to Sir William Willcocks, "not "honest-looking postcards," and he regarded them as forgeries. He called particular attention to the absence of stamps from two of them and the suspicious appearance about the stamp of a third. One of the cards without a stamp was an important one, since it contained the week's readings ending January 31st, 1914, and according to Sir William, if it had not been actually posted on that date, it could not have reached Khartum in time for Mr. Landon to have had the reading for January 31st, which, according to his letter above-mentioned of February 4th, he had given to Colonel Kennedy on this latter date. The dates of the other two cards criticised had no special significance. Now if Sir William had been alleging that the January 31st card only was forged, the absence of the stamp might be suspicious, but his case depends on the whole series being forged. Is it likely that a forger would have produced a series of cards, all duly stamped and postmarked except two? Perhaps Sir William meant to suggest that, having forged Landon's letter and the cards, the forger found that his postmark on the critical card would not fit, and tore the stamp off that card and another one to keep it company; but this, besides making him a clumsy forger, neglects the existence of other date stamps on the cards, and it is really a very wild surmise in the face of the sworn testimony of eight or nine witnesses. It was stated by one of the witnesses that complaints had been made on other occasions of clerks taking off the stamps. No reason was suggested why the card in question should not have been posted on the 31st, the day on which its last reading was recorded.

Criticisms were also levelled against the Wad Medani gauge book on the ground of the uniformity of the writing and ink, which I do not think is borne out by an examination of the book; and against the Khartum gauge book, on the ground that the material pages had been gummed in. The book appears to be in bad condition, owing to hard wear, and the witness who kept it gave a perfectly reasonable explanation that some of the pages had become detached, and he had gone through the book and repaired it with gummed slips wherever necessary. After seeing the book, I have no hesitation in accepting this explanation. The evidence of all these witnesses was criticised, though two of them were not cross-examined, and Sir William Willcocks spoke of them "as well-drilled witnesses." I said in court, and I repeat here, that I do not think there was any foundation for this suggestion. These witnesses, in my opinion, gave their evidence well, some of them answered what must have been quite unexpected questions in cross-examination readily and intelligently, and there was nothing to indicate that they were telling a carefully prepared or concocted story. Sir William Willcocks would not call them "liars," but only "Government "officials," and does not shrink from the suggestion that not only these subordinates, but the higher English officials, must be assumed to be ready to perjure themselves in court rather than be obnoxious to their chief. Unless Sir William is prepared to concede that this would have applied to himself when he was a Government official, he has no right to postulate it of others. He is driven to this by what is one of the strongest points against him on this as on other parts of his case. He constantly insists that Sir Murdoch MacDonald, and Sir Murdoch MacDonald only, is guilty, but it is materially impossible that Sir Murdoch MacDonald should have committed these pretended forgeries and frauds without the assistance and connivance of a large number of officials, high and low, and with the knowledge, almost certainly, of a great many other people. Yet not one single witness comes forward against him or gives him away when called in his favour. If the charges were well founded, how many anonymous letters or offers of assistance would not Sir William Willcocks, to say nothing of the Commissioners, have received? But Sir William has never even hinted that he has received inside information which he cannot use, and it is to be supposed that he would have done this in his books if anything of the kind had occurred. I accept without hesitation the evidence of the witnesses called, who proved the above-mentioned books and documents, nor have I any doubt that those books and documents contain the readings of the Sennar gauge as recorded and reported at the material time. It will be seen that this conclusion is only made more certain by other elements of the defence, which I shall deal with presently in connection with the allegations as to exaggerated discharges.

The second part of Sir William Willcocks' first charge is really a corollary of the first part, since the only intelligible purpose of the falsification of gauge readings is an intention to use them as the basis of exaggerated calculations of the amount

of water coming down the Blue Nile. It has been explained to me that, if it be desired to ascertain the "discharge" or amount of water (usually measured in cubic metres per second) passing any point in the course of a river, this may be done in two ways—by actual measurement, or by computation from the reading of a gauge showing the height of the river referred to a table or curve prepared from previously obtained measured discharges. Measured discharges are obtained by finding the depth and measuring the mean velocity of the water at frequent intervals across the river. The total discharge can then be determined from the cross-section of the river obtained from the soundings, and the mean velocity. Formerly mean velocities were obtained by measuring the time taken for a float to pass over a given distance. This gives the surface velocity, from which the mean velocity can be obtained approximately by making certain assumptions. More recently, floats have been replaced by an instrument known as a current meter, which is immersed in the water to the depth where it is known that the water has the mean velocity of the vertical section. (It is unnecessary here to speak of the special system of measuring by "sluice discharges" practised at Aswan.) From such measured discharges a table can be prepared which will give an approximation to the discharge which may be supposed to be passing for any given river level shown on the gauge. But the river level or gauge reading may be affected, without reference to the volume of water passing, by changes in the river bed caused by erosion or silting, either at the gauge itself or above it or below it, the most easily comprehensible effect being that of a banking up of the water caused by a sandbank forming below the gauge. This is really the same point as is involved in the first part of the charge based on the comparison of Sennar and Roseires gauge readings. It is evident that the method of obtaining discharges by reading the gauge and referring to a table is liable to error in a degree proportionate to the probability of changes having occurred in the river bed.

Witnesses were called to prove that at the end of 1913 and beginning of 1914 a series of measured discharges, by current meter, were taken at Soba and Wad Medani, on the Blue Nile, distant respectively 338 and 154 kilometres down stream from Sennar. The point was brought out in cross-examination that the witness Abdel Fattah, who took some of these observations, had never used a current meter before; but I am concerned here, not with the probable accuracy of the observations, but with the question whether the published figures represent observations honestly made at the time.

From these observations, Mr. Hurst, the head of the Physical Department, in 1917 prepared for Sir Murdoch MacDonald a diagram showing the Blue Nile discharge for Sennar over the period December 17th, 1913, to March 2nd, 1914, as a "curve" which is in fact, for the period December 17th to February 18th, very nearly a straight line. For reasons which he gave in evidence, Mr. Hurst considered that these Soba and Wad Medani discharges represented the discharge at Sennar. This diagram, signed by Sir Murdoch MacDonald and dated "20/5/17," was given to Colonel Kennedy, who was criticising the scheme on the ground of insufficient water in low years, and forms the basis of this part of Sir William Willcocks' first charge, as well as of other charges brought by him and Colonel Kennedy. Taking the discharges recorded on this diagram, Sir William plots them on a new diagram against the official Sennar gauge readings for their respective dates, and also against what he calls the "actual" Sennar gauge readings already mentioned, *i.e.*, his view of what they ought to be, deducing them from Roseires. On the same diagram, Sir William plots two other discharge curves, which he calls "Hurst's discharge curve of 1912" and "Willcocks' discharge curve of 1920." The result is that, while the two latter curves show a uniform, or nearly uniform, concavity, the curves obtained from the official discharges show an outward or convex bulge—and it is to be noted that the curve obtained from the official discharges compared with Sir William's "actual" gauge readings shows a much more pronounced bulge than that which is obtained by plotting the official discharges against the official gauge readings. On his diagram Sir William writes: "It is physically impossible for discharge curves to be *out* curves. They can only be *in* curves, like Hurst's and Willcocks'." It was easily shown by the Public Works Department, by producing discharge curves obtained on other rivers as well as on the Nile, that as a general proposition this statement is not true; and this was admitted by Sir William, who said that he never intended it to be supposed that he applied it otherwise than to this particular place, Sennar, at this particular time of the year, and

after a low flood when there is little silt in the river. The argument again depends on the supposition that Sennar is a peculiar spot where changes in the river bed under these particular conditions are next door to impossible. Sir William was constantly insisting on the rocky bar, which is said to exist at Sennar itself, as being incapable of being eroded, and the suspicion crossed my mind that when he first put forward these arguments he had not fully considered the possible effects of changes above and below the site. Assuming that he had, I gather that it is dangerous to found on the fact—if it be a fact—that changes have not occurred at or near Sennar during a certain number of low years the inference that changes never will take place there in a low year at this stage. I have mentioned that the official discharges plotted against Sir William's "actual" gauge readings give a more impossible curve, on his line of argument, than the same discharges plotted against the official, and supposedly forged, gauge readings; Sir William is therefore bound to treat the official measured discharges as inventions or exaggerations, and, in order to obtain what he calls "actual" discharges on which to base his percentage of alleged exaggeration, he resorts to a calculation, to which Mr. Maxwell applies the description of "mental gymnastics." Having thrown over the official 1913—14 figures, with the exception of the Roseires gauge readings and that portion of the Sennar gauge curve which he accepts as accurate, and supplements with his "actual" Sennar readings already described, he takes the official discharge figures for Sennar during 1919, which he assumes to be accurate, and plots them against the 1919 official gauge readings reduced by 35 centimetres, this reduction being made because he has decided from another line of argument (also dependent on a want of concordance between measured discharges and a discharge table) that the Sennar gauge itself was bodily lowered by 35 centimetres with fraudulent intent when it was rebuilt in 1916. This point forms the subject of his fourth charge, and will be discussed later; it is sufficient to say here that the Commissioners are satisfied that the level of the gauge scale has not been altered. In this way he obtains the curve which he has entered on his diagram, already referred to as "Will-cocks' gauge curve, 1920." He then takes his so-called "actual" Sennar gauge readings for 1913—14 and, by comparing them with this curve, obtains "actual" discharges for 1913—14, on which he bases his exaggerated percentage mentioned in the charge. Such an argument could at best be used as confirmatory of strong direct evidence of the falsification of gauge readings and the alteration of the gauge level: in the teeth of the sworn testimony of a number of witnesses, no weight at all can be given to it. I am glad to have my view on this point confirmed by the fact that the Technical Commissioners see no difficulty in supposing that some change in the river bed sufficient to explain the peculiar form of this discharge curve really took place.

The concluding part of this charge refers to the loss, by which is presumably meant suppression, by Sir Murdoch MacDonald of a "public document of prime importance," viz., the "Blue Nile Memorandum." This is hardly a matter about which the Commission is called upon to express an opinion, and I will only point out that the memorandum was a semi-private document conveyed to Colonel Kennedy for his personal information, under cover of a private letter which he tore up.

Before discussing Sir William Willcocks' second and Colonel Kennedy's fourth charge, which run together, I propose to deal with the line of defence which was put forward, and which is applicable not only to these first, but to other charges based on absence of motive. The charges as a whole allege, in fact, a conspiracy on Sir Murdoch MacDonald's part to attribute by fraud exaggerated discharges to the Blue and Main Niles in low years in order to bolster up the Gezira Irrigation Scheme, which was being criticised by Colonel Kennedy on the ground of insufficiency in low years of the Blue Nile water supply.

Mr. Maxwell put in a number of documents, letters, reports, and so forth, bearing on the history of the Gezira irrigation scheme from 1913 onwards, with the object of showing that, from 1914 onwards, and particularly after 1916, when the question of the Sennar discharges seems to have been seriously considered by the Public Works Department in reply to Colonel Kennedy's criticisms, no attempt has ever been made to justify the discharges officially attributed to Sennar by reference to the official Sennar gauge readings, which are alleged to have been forged for this purpose. Forgery implies the intention to make use of the forged material for the purpose of deceiving

somebody, and apart from the question of a defence at law to the charge of forgery, with which we are not concerned, it is common sense that the absence of any attempt to make use of these supposedly false gauge readings would be very strongly corroborative of the defence that they never were in fact falsified. I think Mr. Maxwell has clearly established his point, and although I do not think any serious attempt was made to combat it, I will refer to some of the material documents. On February 10th, 1914, Colonel Kennedy says that he received the report of the Commission on the Gezira scheme (dated 25/1/14, and supplementing a report of 4/9/13), and he was immediately struck by the fact that the Sennar gauge readings at that period already showed a level much lower than that recorded in 1908, on which, he says, the scheme was based as a minimum year, and that, on a comparison of the latest gauge reading with the discharge table then in use, he found the discharge to be sixty-six tons per second as against 238 tons per second for the same date in 1908. He immediately drew the attention of the Governor-General to this fact, and on February 25th received from the Governor-General the "Blue Nile Memorandum."

It is not stated in Colonel Kennedy's pamphlet, nor did he state in evidence, from exactly what point of view he considered that the decreased water supply would be fatal to the scheme or what the "allegations" were which he declares to have been reported on by a committee appointed in the Sudan during his absence at Gallipoli. These allegations may, therefore, be supposed to be immaterial to the present inquiry. But it is clear that the question of water supply was at different times considered by the Public Works Department from the point of view of the effect of the scheme on Egypt's water supply, and from that of the sufficiency of water for the scheme itself. On February 10th, 1914, Sir Murdoch MacDonald had written to Mr. (now Colonel) Cooper, then inspector in charge of the Beheira projects, asking for a note on the effect of the Blue Nile dam and canalisation scheme on the water supply of the main river, and this was supplied on March 31st, 1914. Meanwhile, in the "Blue Nile Memorandum," Sir Murdoch had referred to the question of the Blue Nile discharge mentioned by Colonel Kennedy, and, accepting Colonel Kennedy's quoted gauge reading of 10.06, had suggested that the application of a correction for erosion would give at least double the discharge calculated by Colonel Kennedy. On receipt of Colonel Cooper's note of 31/3/14, Sir Murdoch prepared a note on the same subject for the Egyptian Legislative Assembly, probably some time in April, and on the assumptions which were then being made as to storage capacity and requirements of the scheme, which was not expected to draw on the storage after March 15th, he concluded that, even in the most exceptional years, such as 1913—14 and 1899—1900, the construction of the Blue Nile dam would have no effect in reducing the summer water supply in Egypt unless an area of over 500,000 feddans were cultivated, the project being then for 100,000 feddans of cotton, or 200,000 in all. No attempt to justify the conclusion by means of discharge figures was made. Nothing further on the subject appears till July 18th, 1916, when Sir Murdoch MacDonald prepared a more elaborate note on the Sudan water supply, in which he examined the questions whether Egypt could afford to let the Sudan take water from the Nile and whether, assuming that Egypt could allow it at certain seasons, there was enough water in the Blue Nile to meet the Sudan requirements. Colonel Kennedy had been away till the autumn of 1915, and this note may be connected with his renewed criticisms during the winter of 1915—16 and his correspondence with the Governor-General of the Sudan, beginning, he says, with his letter of May 22nd, 1916.

It is also to be remembered that this note of July, 1916, was produced some months subsequently to the date at which Mr. Nasce, the Italian engineer who gave evidence before the Commission, had rebuilt the Sennar gauge, and, according to Sir William Willcocks, had lowered the scale by 35 cm. It might therefore be expected, if the charges were well founded, that we should find Sir Murdoch referring to the Sennar gauge readings in justification of the supposed volume of the Blue Nile discharge. Nothing of the kind is to be found in the document. What he says is, "The Blue Nile volume, so affected at this critical period" (*i.e.*, February and March, mentioned in the preceding paragraph), "may drop to 65 cubic metres a second." This estimate of 65 cubic metres a second, it is clear from the evidence and other documents produced, was the result of the measured discharges taken at Soba and Wad Medani in 1914. The lowest such discharge worked out, in reality, at 62 cubic metres per second, which we were told was rounded off to the figure 65 in this document and to the figure 60 in another document of later date. There is no mention of discharge tables or gauge

readings in the document, and it appears from later paragraphs that Sir Murdoch's opinion was that, even if the Blue Nile were absolutely to fail over the three months January, February, and March, it would still be possible to meet the failure and counteract its effects. I am not concerned with the soundness of this opinion, but it does seem to me difficult to suppose that a man who was prepared seriously to put it forward should then be engaged upon a complicated system of forgeries in order to show that the Blue Nile during those months carried more water than was really the case.

A series of letters was put in which passed between the Acting Director-General of the Gezira Irrigation Scheme and the Acting Under-Secretary of State for Public Works (Sir Murdoch MacDonald being away) during the late summer and autumn of 1916 on the subject of the water duty of the proposed irrigation canal as affecting its design. There is no indication that the writers were concerning themselves about the amount of the river discharge, but on November 25th, 1916, Sir Murdoch MacDonald prepared a further note on the Gezira canalisation scheme and water supply, and design of main canal. This note was forwarded to the Governor-General of the Sudan (Sir R. Wingate) as a continuation of the note dated 19/7/16, and it forms the basis of Colonel Kennedy's fifth charge, which accuses Sir Murdoch MacDonald of deliberately framing a false record or writing (to wit, his note dated November 25th, 1916), knowing he would thereby cause loss and injury to the public. The sentence in the note to which Colonel Kennedy takes particular exception is as follows:—"The available volume is 65 metres cube, to which the river has been known to drop only once in 150 years. Obviously there is enough water for cotton in these very worst of circumstances, as it takes 58 metres cube only." Sir Murdoch MacDonald stated, in his covering letter to Sir Reginald Wingate, that he had prepared the supplementary note because considerable variation of opinion had arisen in regard to the quantity of water which might be required for irrigation, so that he felt, whatever his own opinion might be, that it would be as well, by taking the maximum requirements suggested into account, to show that there was, even with these figures, an ample supply in the river to meet the needs of the 300,000 feddans. Sir Murdoch sticks to his previous figure of 65 m.³ as the lowest discharge during the critical period. Previous to drawing up his note of 25/11/16, Sir Murdoch had obtained a note, accompanied by tables prepared by the late Mr. E. W. Buckley, dated November 2nd, 1916, from which it appears clearly that the discharges given in the tables were obtained from actual observations at Soba. Sir Murdoch adopts a much higher figure than in his previous note for the requirements of the Gezira irrigation scheme, but he still gives it as his opinion that there will be an ample margin. There is, again, no mention of discharge tables or gauge readings. At some date in November before the preparation of the note of 25/11/16, Colonel Kennedy had had an interview with Sir Murdoch MacDonald, at which he says that he offered to give the latter materials which were refused. Sir Murdoch states that Colonel Kennedy presented himself as an emissary of the Sudan Government, but that he was not satisfied as to Colonel Kennedy's credentials.

On December 28th, 1916, Sir Murdoch again writes to the Governor-General on the subject, and gives 60 m.³ per second in 1914 as the lowest record at the critical stage in March, which coincided with the lowest river recorded in Egypt for 150 years. On May 12th, 1917, Mr. E. Bonham Carter, then Legal Secretary to the Sudan Government, wrote to Sir Murdoch MacDonald to say that General Stack (who had become Acting Governor-General) would like a short note or letter on the points raised by Colonel Kennedy, the first of the points enumerated being the sufficiency of the water for the Gezira project as then contemplated. On May 20th Sir Murdoch MacDonald replied with three notes addressed to the Private Secretary, the first of which deals quite shortly with the question of water supply. To that note was attached the diagram already mentioned, prepared by Mr. Hurst, which, Sir Murdoch says, shows that the amount of water available is even greater than mentioned in his previous notes and letters. Again, there is no attempt to justify by means of discharge tables or the Sennar gauge readings, and Mr. Hurst has sworn that the diagram was prepared on the measured observations taken at Soba and Wad Medani. The original diagram signed by Sir Murdoch MacDonald on 20/5/17 does not show the individual discharges, but a copy was prepared by Mr. Hurst at the time which shows the actual observations. On February 23rd, 1918, Colonel Kennedy appears to have lodged a formal "complaint" against Sir Murdoch MacDonald under a section of the Sudan Penal Code with the

Governor of the Khartum province, the charge being based on this diagram of 20/5/17, and being, in effect, the same as the sixth charge filed by him with the Commission. On May 22nd, 1918, Colonel Kennedy writes to the High Commissioner for Egypt to bring to his notice a complaint with which the Sudan Government has omitted to deal. In this letter he explains his charge in some detail. After stating that the portion of the diagram which is more obviously falsified is that portion of the upper diagram marked "Sennar discharge, 1914," and that the discharges shown on the document are not the discharges obtained from the official records, he goes on to say, "The two diagrams on the document under consideration have been prepared from the Sennar Gauge Discharge Table of the Egyptian Public Works Ministry applied to the officially recorded Sennar gauge readings of the various years dealt with in the two diagrams."

"The official 'Sennar Gauge Discharge Table' is that table which was used by the Irrigation Department and by myself in preparing in 1913 the various projects for the Gezira irrigation scheme; it is the table that held good when these projects were discussed at various conferences at the British Agency, Cairo, in June, 1913, when Lord Kitchener went into the matter in detail with the Egyptian Government Irrigation Authorities and myself; it is the table that held good when the Gezira irrigation scheme was investigated by the Commission appointed to consider that scheme, and which was in official use when that Commission, on January 25th, 1914, recorded its decision regarding the scheme; and, finally, it is the table from which the attached document (*vide* plan at end) was prepared."

"The diagrams for the various years dealt with on the attached document up to 1914 are in reasonable accordance with the official table, but for 1914 the document not only is not in accordance with that table, it is not in accordance with any table that could possibly be devised if applied to the official Sennar gauge readings of that year."

"One example capable of being verified in a couple of minutes from the official records will demonstrate the comparative extent of the falsification. The Sennar gauge reading for January 24th, 1914, as officially recorded, and as officially furnished me on February 4th, 1914, in my capacity as Director of the Public Works Department of the Sudan Government, was 10·10 metres."

"The official Sennar discharge table gives a discharge of 70 metres cube per second for this gauge reading. This figure—namely, 70 metres cube per second—has, however, been falsely recorded on the attached document as 110 metres cube per second, thus making the river appear to discharge 57 per cent. more water than the official records demonstrate it did discharge on that date."

"If the Egyptian Public Works Ministry contends that this is not a falsification, and that the official Sennar discharge table shows a discharge of 110 metres cube per second for the Sennar gauge reading of January 29th, 1914, officially given as 10·10, how can the Ministry explain the fact that at the lower end of the line marked 'Sennar discharge, 1914,'—*i.e.*, in April, 1914—it is recorded on the same document that for the same gauge reading at Sennar (*viz.*, 10·10) the discharge is 56 metres cube per second, *i.e.*, approximately only half what is shown on the same document for the same gauge reading (*viz.*, 10·10) on January 24th of the same year, 1914?"

To this letter a reply was sent to Colonel Kennedy, dated July 10th, 1918 (No. 142 in his "annexe to Bulletin No. 2," lodged by him with the Commission), covering two notes, one by Mr. Prowde, Director-General Blue Nile Division, stating that the officially recorded Sennar gauge reading for January 24th, 1914, both at Sennar and Khartum, was 10·20, and the other by Mr. Hurst, dealing with both Colonel Kennedy's points. Mr. Hurst's note states:

- (1) That the diagram was not based on the table of which Major Kennedy talks but with the exception of 1914 on a new one got out independently by the Physical Department.
- (2) That the curve for 1914 was drawn from actually measured discharges.

Mr. Hurst further points out that Major Kennedy's gauge reading for January 24th, 1914, was wrong (giving a number of readings for days adjacent), and that, in any case, it would be unsound to apply to 1914 a discharge table based on years when the levels had never fallen so low; and, as to the allegation about the April discharge for the same gauge reading, that the diagram only goes to April 16th, and that the levels recorded about that date, and up to the 29th, were all below 10 metres. We have no evidence as to the source of Colonel Kennedy's supposed April reading of 10.10.

On receipt of this it appears that Colonel Kennedy added to his charge of falsification of discharges the charge of falsification of the gauge readings, in which he has since persisted.

It is quite evident from this correspondence, and particularly from the letter of May 22nd, 1918, that Colonel Kennedy imagined that what he calls the "official discharge table" was the only possible basis of the discharge curve shown on the diagram, and that it was a kind of law of the Medes and Persians; so that it was enough to expose the discrepancy between published discharges and the table in order to convict the Public Works Department of falsification. It will have been understood from what has been previously said that this is, in the opinion of the Commissioners, a quite untenable position.

I have dealt with this point at some length because it shows the possibility, at any rate, that Colonel Kennedy's charges were originally made under a misapprehension; and it also shows, unless one were to discard every shred of evidence produced by the Public Works Department, that there was never any thought of showing exaggerated discharges by means of the falsification of gauge readings. The sequence of documents I have quoted, obviously genuine, is, in my opinion, the strongest possible testimony to the good faith of the Department.

I now proceed to the consideration of Sir William Willcocks' second charge, which is the same as Colonel Kennedy's fourth. It runs as follows:—

"1. I accuse Sir Murdoch Macdonald, adviser to the Ministry of Public Works, of publishing false and exaggerated figures for the discharge of the Nile. These are given on page 11 of the Report of the Ministry of Public Works for 1912, printed in 1914, and given to the public. It is stated there that the mean supply passing Aswan was as follows, as calculated from sluice discharges at the dam:—

" April	602 cubic metres per second.
" May	580 " "

"The real figures as calculated were given in 'The Annual Report of the Inspectors-General of Irrigation for 1912,' published in 1914, and not given to the public. They are:—

" April	532
" May	512

"2. I accuse Sir Murdoch Macdonald of losing a public document of prime importance in connection with these figures."

The short answer of the Public Works Department to this charge is that a mistake was made, an admittedly serious mistake which cannot now be accounted for, by the use by Sir Murdoch MacDonald, in the part of the Report which was published, of the figure of 33 cm. as a correction for erosion, whereas the correct figure as reported by the Resident Engineer at Aswan was 17 cm. This explanation has been made on oath, and must, I think, be accepted, and its good faith receives strong confirmation from the explanation which Sir Murdoch MacDonald is able to give as to the non-publication of the Inspectors-General's Report for 1912, and also from the fact that it is not suggested that any particular use has ever been made of the erroneous figures, nor has any special motive for the publication of this particular error been suggested.

It is necessary to deal shortly with the allegation made in connection with this charge that the report of the Inspectors-General for 1912, which contains the correct figures, was intentionally suppressed. For the years previous to 1912 the report of the Inspectors-General had always been published with the Advisers' Report, and as an annexe to it. On March 23rd, 1913, before the report for 1912 had been published, a note was put before the Council of Ministers by the then President of the Council, Mohamed Pasha Said, and was approved, to the effect that no report of any functionary should be published till it had been submitted to the Council of Ministers. In correspondence which ensued, it was laid down that the whole of the Public Works 1912 Report must be submitted before publication. Later on the Council of Ministers found that the difficulty of translating and examining voluminous technical reports written in English was too great, and it was ordered that Departments should publish only a *résumé* of those matters dealt with in their reports which were of public interest, and that the records of other matters should no longer be printed. (Letter of President of the Council to Minister of Public Works, 19/6/13.)

On July 14th the Minister of Public Works wrote to the President of the Council pointing out that the reports of the different departments of his Ministry were of the greatest value for future reference, and asked that they might be allowed to be printed, but not put on sale. The question evidently dragged on, and on November 18th, 1913, a letter was written by Mr. Molesworth, one of the Inspectors-General, protesting against a decision of the Ministry of Finance not to allow the printing of the Inspectors-General's report. On November 20th there was a letter from Mr. G. B. Ireland, another Inspector-General, on the same subject, and on the same date, Mr. Williams, Inspector-General at Headquarters, wrote to Sir Murdoch MacDonald, the Under-Secretary, pressing him to see the Financial Adviser about it. On November 22nd Sir Murdoch wrote to Lord Edward Cecil, then Financial Adviser, on the subject, but it was not till December 20th that Lord Edward Cecil replied with a reluctant consent. On January 6th, 1914, the Inspectors-General's reports were sent to the press with an order for 129 copies, and evidence was given that these were kept for official use with the exception of a few copies supplied to ex-Government officials and the Indian Government. Sir William Willcocks did not receive a copy. This makes it perfectly clear that there was never any intentional suppression of the reports of the Inspectors-General for 1912, and that they were printed as soon as the Department obtained permission to do so. They were not published because the Council of Ministers would have nothing published which it had not approved, and the difficulty of translating and approving these technical reports was too great. Another point made by Mr. Maxwell in connection with this charge is worth mentioning; he showed that, in other cases where the Under-Secretary's and Inspectors-General's reports had been published together, differences were to be found in the figures given for the records of the same data.

In view of the above explanation, the point as to the loss, by which is meant suppression, of a public document of prime importance, *i.e.*, the Aswan Emptying Table for 1912, ceases to be of importance; and, in any case, its loss was not proved.

Sir William Willcocks' third charge, to which at different times he added three appendices, runs as follows:—

“The discharges of the Nile, measured by sluices at Aswan and assigned to the “low months of 1916, the last low year recorded in ‘Nile Control,’ as compared with “discharges credited to the Nile at Halfa, are greatly exaggerated.”

In connection with this charge, it is sufficient to say that the Technical Commissioners consider that the method of measuring the Aswan discharge by taking “sluice discharges” is the most accurate method of measuring very large discharges employed anywhere in the world; that the only evidence for exaggeration is the alleged want of correspondence of the figures, as compared with former years, with Wadi Halfa discharges (350 kilos. distant) obtained from a discharge table, and that, as has been seen already, discharges calculated from a discharge table can at best be considered only as approximations. The charge and the appendices will be discussed in the report of the Technical Commissioners, and I do not propose to refer here to the appendices, which are of the nature of criticisms of the accuracy of the data rather than charges of fraud.

Sir William Willcocks' fourth charge runs as follows :—" The new Sennar gauge on the Blue Nile has been lowered by 35 cm. compared to the old gauge which was read from 1906 to 1914.

" By this action the Blue Nile has been credited with exaggerated discharges in normal years ; and all low years are practically normal at Sennar. In a normal year a gauge of :—

" 11·00 is discharging about 171 cusecs, and is credited with 292 in the official table.

" 10·50	"	"	71	"	"	140	"	"
" 10·00	"	"	27	"	"	60	"	"

In support of this charge Sir William Willcocks says that he noticed that the published figures for the gauge readings of Malakal (on the White Nile) and Sennar (on the Blue Nile) in the low years 1919 and 1920 did not show the same relations respectively with the gauge readings for Khartum and Tamaniat (at or near the junction of the two rivers) as they had done in low years before 1914. (he quotes one reading only for each gauge for each of the respective periods, but it may be supposed to be a type reading). Being convinced that it is safe to assume that no correction for scour or silt is to be made " at " any of these four gauges in the low-summer which follow the poor floods, he concluded that the zeros of the new gauges had been deliberately lowered with the object of crediting the river with exaggerated discharges. The argument again rests on the very unsafe assumption of no changes in the river bed, either slow or sudden ; and on the further supposition that the only means of calculating discharges to be adopted is the use of a table. Sir William then asked the Commissioners to let him take a discharge in their presence at Sennar, which was done on March 14th, 1920. Because the measured discharge so taken did not agree with either of the two discharge tables to which he referred it, he concluded that the Sennar gauge scale had been dropped 35 cm. The Sennar gauge had been rebuilt at a short distance from its old site, according to the Public Works Department, because it was under some railway sheds and boats used to tie up there and damaged it. The level of the masonry steps of the new and old gauge sites were compared by means of an instrument in the presence of the Commissioners, and by an extraordinary coincidence there was a difference of about 35 cm. This was, however, subsequently explained, to the complete satisfaction of the Commissioners, by the facts that the old gauge steps ran from half-metre to half-metre, while the groove in which the actual gauge scale had been formerly set did not reach the bottom of the step by about 15 cm. ; the new gauge steps were arranged to run from metre to metre, with the bottom of the gauge scale level with the bottom of the step, with a resulting difference of 35 cm. in the level of the step. Mr. Nasce, the engineer who rebuilt the gauge, was called as a witness, but even without his evidence the Technical Commissioners had satisfied themselves that the level of the gauge scale had not been altered in rebuilding it. Sir William Willcocks attempted to found a further argument in support of this charge on some inaccuracies in the figures and drawings on the plan prepared at the time by Mr. Nasce and approved by the late Mr. Buckley, which was produced at the hearing, and Colonel Kennedy suggested that Mr. Nasce had been previously convicted of careless work, which was denied. There can be no doubt, however, that Mr. Nasce was ordered, as he declared to us, to rebuild the gauge to the old level, and that he did so to the best of his ability. He explained to the Commissioners how he had transferred his levels, and produced his original levels book.

Sir William Willcocks' fifth charge consists of a rambling statement, which is not easy to follow ; the gist of it is that from 1915 onwards the recorded gauge readings of the Blue and White Niles represent a discharge for the main Nile which is not borne out either by the gauge readings previous to 1915 or by those of Khartum or Wadi Halfa. It is supported by arguments from statistics pure and simple, and, in conclusion, Sir William says that it " looks like a conspiracy to bewilder and confuse Egypt and " prevent her from sifting out the reason why the recorded gauges for the Blue and " White Niles indicate excellent supplies, which the actual supply arriving at Halfa " flatly contradicts."

This charge will be found dealt with in the report of the Technical Commissioners, who consider Sir William's methods of proof very unsatisfactory. It hardly amounts to a charge of fraud, and I shall not make any attempt to discuss it here.

The same applies to Sir William Willcocks' charge No. 6, which is also complicated, and involves an appreciation of arguments from statistics rather than of the value of evidence called at the hearings, so that it is best left entirely to the Technical Commissioners.

It remains only to speak of the three charges of Colonel Kennedy which were lodged with the Commission, but with which he said he did not wish to proceed further at the close of the case on Sir William Willcocks' charges. Two of these charges, Nos. 5 and 6, are in reality closely connected with the first charge of Sir William Willcocks, and refer to the Sennar discharge. Colonel Kennedy asked questions on them in cross-examination, and the Commissioners are in possession of sufficient material to form an opinion on them. I have already referred to them in that part of my opinion which deals with Mr. Maxwell's point as to absence of motive on the first group of charges. No. 5 accuses Sir Murdoch MacDonald of framing a false record or writing in the shape of his note of November 25th, 1916, knowing that he would thereby cause loss or injury to the public. The particular point taken is the falseness of the statements contained in the sentences: "The available volume is 65 metres cube to which the river has been known to drop only once in 150 years. Obviously there is enough water for cotton in these very worst of circumstances, as it takes 58 metres only." Colonel Kennedy complains that 65 metres cube is not the lowest recorded discharge in the Blue Nile, and this is met by the answer that Sir Murdoch MacDonald was speaking only of what he calls the critical period, January to end of March, and was referring to mean discharges and not single observations. Lower discharges after the end of March are recorded on the diagram signed by Sir Murdoch on 20/5/17 and given to Colonel Kennedy. Then Colonel Kennedy objects that there are no records of the Blue Nile for 150 years; the answer is that Sir Murdoch, who expressed himself loosely, meant that this lowest recorded discharge of 65 m.³ in the critical period corresponded with the year in which the Nile flood measured at Roda, near Cairo, attained its lowest maximum level for 150 years. Colonel Kennedy takes further exception to the statement that cotton takes 58 m.³ only. It is clear from the note and the other documents put in that Sir Murdoch MacDonald found himself in the presence of considerable difference of opinion as to the true requirements in volume of water for the Gezira irrigation scheme; he had previously based himself on a much lower estimate, and he now says in the document under discussion and its covering letter that, in order to be on the safe side, he adopts a figure which he considers to be an extreme allowance and which he does not believe will ever be required. It is a question of opinion, and, on the documents put in, there is no reason whatever for supposing that Sir Murdoch's opinion was not honestly given; he adopted very nearly the maximum of three different estimates.

Colonel Kennedy's charge No. 6 alleges that every original line of the diagram signed by Sir Murdoch MacDonald, over date May 20th, 1917, is either a falsification or is grossly inaccurate in the face of the official facts and records, and that the document was knowingly so framed. I have dealt with this allegation sufficiently in the earlier part of my opinion, and have given the reasons for which the charge must, in my opinion, be deemed unfounded.

Colonel Kennedy's seventh charge was not dealt with in any way at the public hearings. It will be found referred to in the report of the Technical Commissioners.

(Signed) G. ARTHUR W. BOOTH.

We fully concur in the above opinion and findings.

F. ST. J. GEBBIE.
H. T. CORY.
G. C. SIMPSON.

August 25th, 1920.

CHAPTER II.

**Report on Charges brought by Sir William Willcocks and Colonel Kennedy
against Reliability of Data.**

THE "opinion" of Judge Booth expresses clearly the conclusions reached by the Commission and discusses in sufficient detail the general evidence placed before it. It has been thought desirable, however, to place on record the results of an investigation of the charges from the purely technical point of view. This investigation has involved a considerable amount of research and it has been necessary to consult a large mass of data recorded by the Physical Department.

Sir William Willcocks frequently uses several lines of reasoning to support a single accusation, but the Commission feels that it is not necessary in this report to follow every one of these lines. An endeavour has been made to use broad lines of reasoning, and when it is possible by a logical argument to answer a charge this only has been set out at length. Thus, for example, many of Sir William Willcocks' points in his discussion of his fifth charge are not specifically referred to, because it is possible by an entirely new line of reasoning to show that the charge itself is unfounded. It must not, however, be concluded from this that these points have not been considered. It can be stated with full confidence that every argument used by Sir William Willcocks and Colonel Kennedy, whether in their oral or written discussions, has received the closest attention and been followed to its logical conclusion by the Commission.

SIR WILLIAM WILLCOCKS' CHARGE No. 1.

Sir William Willcocks left it to the Commission to discover how the three diagrams and the table which he gives support his contention that the Sennar gauge readings taken between early in December and early in February, 1914, have been altered. From what he said during the examination it appears that the following gives a fair idea of his line of reasoning :—

Referring first to Diagram A, this has been prepared as follows. The unbroken curve is plotted from the five-day means of the Roseires gauge, the time scale being given at the bottom of the diagram and the gauge scale on the right of the diagram. The five-day means of the Sennar gauge as recorded in the official file have been shown as a broken curve, but the time scale is five days later than that used for Roseires. The Sennar dates are shown by the upper of the two time scales at the bottom of the diagram, while the Sennar gauge scale is given on the left of the diagram. The five days difference in time is made to allow for the time of travel of the water from Roseires to Sennar.

Comparing the Roseires and Sennar curves it will be seen that whereas before December and after January they run nearly parallel they do not do so between December and January, or as expressed during the enquiry, the Sennar curve during December and January shows a "bump" which is not present on the Roseires curve.

Sir William Willcocks concludes that the true, or actual, gauge readings were as shown by the dot-and-dash curve drawn below the Roseires curve. He is supported in this conclusion by noticing that the gauge readings given in the Blue Nile Memorandum would be obtained from this reconstructed curve.

Turning now to Diagram B, this shows a Sennar time-discharge curve for 1914 as prepared in June, 1918, by Mr. Hurst. It is based on a number of discharge measurements made by current meters at Soba and Wad Medani, the individual discharges being shown by points and crosses enclosed in circles respectively. Although the observations were taken at Soba and Wad Medani, Mr. Hurst feels justified in stating that the observations represent approximately the discharge at Sennar. He has also discussed this point in detail in "Nile Control," pp. 109—111.

From the discharge curve Sir William Willcocks read off the discharges at five-day intervals. He then plotted on Diagram C these discharges against—

- (a) The recorded gauges, and
- (b) The "actual" gauges according to his hypothetical gauge curve.

On the same diagram he has plotted a gauge-discharge curve for Sennar, said to have been prepared by Mr. Hurst in 1912, and another prepared by himself in 1920. On comparing the two former curves, *i.e.*, those based on the official discharges taken in 1914 with those prepared by Mr. Hurst and himself, he noticed that the former were what he calls "out curves" (*i.e.*, convex to the left) while the latter are "in curves" (*i.e.*, concave to the left). He then wrote on the diagram, "It is physically impossible for discharge curves to be out curves. They can only be in curves like 'Hurst's and Willcocks'." It is important to notice that the curve on which the official discharges are plotted against his hypothetical gauge readings is still more of an out curve than that in which the discharges are plotted against the recorded gauges. This proves that the abnormal shape of the curve was not due to the alteration in the gauge readings, but could only be due to the discharges themselves having been falsified. We thus have, according to Sir William Willcocks, that not only were the gauge readings altered, but falsified discharge observations were fabricated.

He then proceeds to determine what were the actual discharges. To do this he first takes the discharge observations made at Sennar during 1919, which he assumes were not fabricated, and plots them against the corresponding gauge readings; but as he is convinced that the gauge scale at Sennar was lowered 35 cm. in 1916 (see Charge No. 4) he deducts 35 cm. from the recorded gauge readings. In this way he obtains the gauge-discharge curve entered on Diagram C as "Willcocks' discharge curve of 1920." Using this curve and his hypothetical gauge readings in 1914 he obtains the "actual discharges 1914 from Willcocks' discharge table" which is plotted on Diagram B, from which he concluded that the official discharges for the period were from 65 per cent. to 80 per cent. in excess.

Reviewing the complicated investigation we see that Willcocks' argument proceeds as follows :—

- (a) The bump on the Sennar gauge curve (Diagram A) during December and January is unreal because it is not shown on the Roseires curve.
- (b) The "actual" gauge readings can be recovered by drawing a curve for Sennar which conforms to the Roseires curve and the reality of this "actual" curve is proved by the data contained in the Blue Nile Memorandum and Colonel Kennedy's evidence as to the reading on January 24th.
- (c) The official time-discharge curve for Sennar based on observations made at Soba and Wad Medani, is clearly impossible, he says, because when the discharges are plotted against the corresponding gauge readings, whether the official or "actual" readings are used, an out curve results, which is a physical impossibility.
- (d) If a gauge-discharge curve is made from the discharge observations made in 1919 and the corresponding gauge readings decreased by 35 cm. (because of the alteration made in the gauge in 1916) the result shows that the official discharges in 1914 were from 65 per cent. to 80 per cent. too large.

The whole of this argument depends on four assumptions :—

- (1) That the Sennar gauge readings during the low period can be deduced in detail from the Roseires gauge.
- (2) That an out gauge-discharge curve is a physical impossibility ("at Sennar after a low flood," Sir William Willcocks added later).
- (3) That a gauge-discharge curve made from observations taken in one year can be applied to another year.
- (4) That the Sennar gauge was lowered 35 cm. in 1916.

There is little difficulty in showing that all these assumptions are unfounded.

The channel of the Blue Nile is capable of passing well over 10,000 cubic metres per second and, in practically every year, the crest of the flood is over 5,000 cubic metres per second. In the period under discussion the flow was only between 160 and 60 cubic metres per second. When the river is so low as this, numerous sandbanks appear all the way from Roseires to Khartum. With such conditions there can be little relationship between the gauge at any one place and the flow, for alterations in the channels between the sandbanks both above and below the gauge will affect the gauge reading for any given discharge. That this is so is quite clear from the seven Sennar discharge curves given in the pamphlet entitled "Computations relating to the 'Note on the Water Supply required and available for the Sudan Gezira Scheme.'" In the Diagram No. 2G, facing p. 32 of that publication, the Sennar gauge readings for a given Blue Nile discharge at the low stage vary as much as 40 cm., which proves the unstable nature of the river channel at low water. Sir William Willcocks considers that because there is a rocky bar across the river near to Sennar there must be a close relationship between the discharge and gauge readings; but on a river of small slope the conditions at the gauge site do not alone determine the flow, sandbanks several miles away may bank up the water at the gauge without altering the flow. The Commission has not the slightest doubt that the bump in the Sennar gauge curve was due to some alteration in the river bed and the facts that a similar bump is shown on all the gauge curves from Wad Medani to Roseires (the bump at Roseires can be clearly seen on Willcocks' Diagram A) and similar bumps appear at the same stage in other years confirm this conclusion.

Sir William Willcocks' statement "It is physically impossible for discharge curves 'to be out curves, they can only be in curves,'" was shown to be untrue by the Public Works Ministry, who produced several examples of out curves obtained on the Nile, Mississippi and the Indus. To these Sir William Willcocks objected on the ground that he was considering only the case of the river at Sennar in low years, and that his statement was not meant to apply to other rivers or other conditions. The Commissioners are, however, unable to accept even this modified statement of physical impossibility. They would agree that with a well-defined permanent channel the discharge curve would necessarily be an in curve; but with a river bed which is changing its form and shape as the river falls, so that the discharge measurements made with the higher gauges refer to a different river bed from those made with the lower gauges, almost any shape of discharge curve is possible.

In the opinion of the Commission the bump on the Sennar gauge curve and the abnormal shape of the discharge curve are both due to the same cause, namely, an alteration in the arrangement of the sandbanks and channels in the river, probably downstream of Sennar.

Turning now to Sir William Willcocks' calculation of what he considers to be the "actual discharge in 1914" (see Diagram B), his assumption that a gauge-discharge table made from observations taken in 1919 can be applied to the river in 1914 is obviously false from what has already been written about the changeable nature of the Blue Nile bed at low water. If, therefore, his gauge-discharge table had been correctly prepared it would be impossible to accept his calculated discharges in place of the observed discharges. But his table was prepared on the assumption that the gauge scale was 35 cm. lower in 1919 than in 1914 and as the Commission cannot accept that the gauge scale was lowered in 1916, there is no other conclusion to be drawn than that Sir William Willcocks' calculated discharges are absolutely valueless.

SIR WILLIAM WILLCOCKS' CHARGE No. 2.

This charge does not involve any technical point and has been fully considered by Judge Booth.

SIR WILLIAM WILLCOCKS' CHARGE No. 3.

We will deal first with the charge itself, leaving the three appendices for later consideration.

The wording of the charge is ambiguous; but there is little doubt that Sir William Willcocks intended definitely to accuse the Public Works Ministry with grossly exaggerating the discharges assigned to Aswan during the low months of 1916.

The Commission went very fully into the method used at Aswan for determining the discharge of the river. Very great progress has been made recently in determining the coefficients of discharge of the various sluices and a short description of this work is given by Mr. Hurst in "Nile Control" (p. 253). Sir Murdoch MacDonald and Mr. Hurst have prepared a long technical paper for presentation to the Institute of Civil Engineers from which it is clear that the discharge can now be calculated with a very high degree of accuracy, when the amount of opening of the sluices and the level of the water in the reservoir is known. The Commission also visited Aswan, where the various operations were examined.

From the data now available Mr. Hurst has recalculated the discharges during the low river period back to 1912, and hopes ultimately to carry the work of recalculation back to the time when the sluices were first used. From this it will be seen that the months forming the basis of this charge—April, May and June, 1916—fall within the period for which the discharges have been revised. The curves and calculations for this period have been specially examined by the Commission and they are satisfied that there has been absolutely no exaggeration of the discharges; on the contrary, they are convinced that there is no other river in the world comparable with the Nile of which the discharge is so accurately determined as is that of the Nile during the low stages in 1916.

On the other hand, the discharges at Halfa are only approximately known for the year 1916, for in the footnote to the table of Wadi Halfa discharges, given on p. 237 of "Nile Control" (and used by Sir William Willcocks), it is stated that the discharge for 1916 is obtained from a general gauge discharge table.

To criticise the Aswan discharges on the ground of discharges obtained from a gauge discharge table for a station 343 kilometres away, with a large reservoir which is being drawn upon in between, is like checking the time of rise of the sun with a Waterbury watch.

SIR WILLIAM WILLCOCKS' APPENDIX A. TO HIS CHARGE No. 3.

This appendix really has no bearing on the charge to which it is attached, as it deals with the condition in 1914 while the charge refers only to 1916.

Sir William Willcocks compares the water which passes down the Nile at Wadi Halfa with that which passes out of the Nile along the various canals, all of which, with one exception, are more than 1,250 kilometres away from Wadi Halfa, and there is a great reservoir in between which is adding water to the natural flow of the river.

In order to make such a comparison it is necessary to have information about the following factors :—

- (a) The time taken for the water to flow from Wadi Halfa to the canals.
- (b) The amount of water which is lost on the way.
- (c) The amount of water which is gained on the way.

(d) The change in the amount of water in the reservoir and in the trough of the river between Wadi Halfa and the canals during the period investigated.

Now there is not a single one of these factors capable of accurate measurement; therefore it is necessary to estimate them. One estimates them from various considerations and these considerations carry different weight to different men. For instance, the method used by Sir William Willcocks to estimate that the loss between Aswan and the canals is 33 cubic metres per second appears to the Commission to be quite indefensible, but it is debatable and could be argued at great length and at the end each of the debaters would, no doubt, retain his original opinion. As a matter of fact there is hardly a single figure used by Sir William Willcocks in his discussion to which objection could not be taken. This question was discussed before the London Committee, where many figures were produced, and, as Sir William Willcocks tells us, he afterwards "accused these figures of being 'arbitrarily manipulated.'" As a matter of fact, such a discussion necessitates manipulation of the figures and such manipulation, if conscientiously carried out, is justified; but, unfortunately, what one side considers legitimate manipulation the other side considers arbitrary manipulation. The whole thing is a matter of opinion and, while the Commissioners do not wish to suggest that Sir William Willcocks has not tried to interpret his figures correctly, their opinion is that the figures used and the method of using them do not lead to any definite conclusion. They are also of opinion that no useful purpose would be served by criticising Sir William Willcocks' figures in detail; it is the whole method that they strongly object to, and they are not prepared to admit that any conclusion reached by such a method is worthy of serious consideration.

SIR WILLIAM WILLCOCKS' APPENDIX B. TO HIS CHARGE No. 3.

In this appendix, Sir William Willcocks states that according to the official figures the loss of water between Khartum and Wadi Halfa was 8 cubic metres a second in 1914 and 113 cubic metres a second in 1919, and implies that this discrepancy proves a "glaring misrepresentation." He does not, however, point out that in 1914 the Wadi Halfa discharges were measured by current meters, while in 1919 they were taken from an uncorrected gauge-discharge table, and, therefore, they are not comparable. Even leaving this out of account the results he obtains do not prove falsification or even bad work, they simply prove that the method itself is imperfect. There are so many uncontrolled factors that individual determinations may, and do, give very discordant results; it is only by making a large number of determinations that a mean value for the loss can be found, and even then this mean value cannot be used for determining the loss in any individual year.

SIR WILLIAM WILLCOCKS' APPENDIX C. TO HIS CHARGE No. 3.

In this appendix Sir William Willcocks criticises the use of current meters. He is under a misapprehension in his first paragraph. The fact that Mr. Hurst finds that "the probable percentage difference of a single rating from the mean of a medium sized Gurley current meter varies from ± 4.6 per cent. to ± 1.9 per cent." has nothing whatever to do with the difference found between the rates determined by the makers and the rates determined by the Physical Service. In the former case the difference is the difference of any single rating from the mean of a number of ratings carried out by the same method, while in the second case the ratings are made by different people using different methods. Mr. Hurst has discussed the difference between the makers' rating and his ratings on p. 250 of "Nile Control," where he says that in the case of small meters the two ratings are practically the same, while in the case of medium sized meters the percentage differences are 10 per cent. at 0.3 metres a second, decreasing to 5 per cent. at 0.75 metres per second and upwards. These are average differences; there is, therefore, nothing strange in the rates of two meters used in the Sudan departing by 14 to 17 per cent. from the makers' ratings at small velocities. It must be admitted that current meter observations taken with low velocities are less accurate than when the velocities are high, and there is room for experiments in this connection. The Physical Service is at present designing new apparatus for calibrating current meters, and no doubt this will be one of the first problems tackled when the apparatus is ready. On the general question of current meters the Commission is satisfied that Egypt is now

employing the method which is approved by irrigation engineers all over the world, and a return to measurements by means of floats would be a serious retrograde step.

SIR WILLIAM WILLCOCKS' CHARGE No. 4.

It is extremely difficult to follow Sir William Willcocks' line of reasoning from the statement he has put in to support this charge. It is, therefore, proposed to restate his case, using the historical method of presentation.

Some time after 1912 Mr. Hurst gave Sir William Willcocks a gauge-discharge table for Sennar, which Sir William refers to as "Mr. Hurst's 1912 gauge-discharge table," although the table was not prepared by Mr. Hurst, but probably by the Sudan Irrigation Service.

Sir William asked the Commission to take a discharge observation at Sennar in his presence. This was arranged, and on March 14th, 1920, the measurements were made. The result showed a discharge of 182 cubic metres a second with a gauge reading of 11.00 metres.

Now, according to "Mr. Hurst's 1912 gauge-discharge table," a discharge of 181 cubic metres a second corresponds with a gauge reading of 10.62. That is a difference of 38 cm. between the actual gauge reading and what would have been expected according to the table.

Sir William Willcocks then examined the gauge. It was a new gauge, the lower part having been built in 1916 and the upper part in 1918. The remains of parts of the old gauge were still *in situ*. Both the old and the new gauges were built in solid masonry steps of one metre each, the actual gauge being engraved on marble plates built into the masonry; but the marble plates had disappeared from the old gauge. Sir William Willcocks noticed that the bottom of each masonry step of the new gauge was lower than the corresponding part of the old gauge and asked for the difference to be measured by means of a level. When this was done it was found that the new steps were 35 cm. lower than the old steps. Sir William Willcocks at once jumped to the conclusion that the new gauge had been built 35 cm. lower than the old gauge, which he considered would explain the apparent difference of level found by the discharge observation. There was no one present at the time who could explain the situation and Sir William Willcocks returned to Khartum thoroughly convinced that he had discovered a falsification of the first magnitude, carried out to make the level of the water appear higher than it actually was by 35 cm., which would, of course, mean an apparently greater discharge than was really the case.

The Public Works officials were able, however, to find the drawings used when the new gauge was built and also the Italian engineer who built it. The explanation of the difference in level of the steps was then clear. The old gauge was built in steps running from half-metre to half-metre, *i.e.*, from 10.5 to 11.5, from 11.5 to 12.5, and so on, but the bottoms of the marble plates, on which the scale itself was cut, did not reach to the bottoms of the masonry steps. It was possible, however, to see in the old steps the grooves into which the marble plates had been fixed, and these clearly ended 15 cm. above the bottom of the masonry steps.

It was decided when designing the new gauge that the steps should run from metre to metre, *i.e.*, from 10.00 to 11.00, 11.00 to 12.00, and so on. In the new gauge the marble plates were placed in their usual position, that is with the bottom of the plates at the bottom of the masonry steps. It will be seen at once that this necessitated building the new steps 35 cm. lower than the old ones.

It may be stated at once that the Commissioners are convinced that this is the correct explanation for the following reasons. They themselves examined the grooves in the old steps, and by levelling satisfied themselves that the bottom of each groove corresponded with one of the half-metre divisions on the new gauge. At the examination in Cairo the drawings for the new gauge were shown, and finally, Mr. Nasce, the assistant

engineer who built the gauge, was examined and stated on oath that he put in the new marble plates as described and explained how he had transferred the levels from the old to the new gauge. His cross-examination by Sir William Willcocks left his testimony unshaken.

When the Public Works officials had found the explanation of the difference in levels of the steps, they asked Sir William Willcocks to return to Sennar from Khartoum to examine the grooves. This he did, but his mind was so firmly made up that nothing would convince him. He returned to Cairo and sought out further evidence to support his case. He obtained from the Physical Department the discharge observations made at Sennar in 1919 and plotted them against the gauge readings *reduced by 35 cm.*, and so obtained a discharge table which he calls the "Willcocks' 1920 discharge table." He then proceeded to show that this table agrees well with the discharge observations made at Sennar in the years 1905, 1908, 1912, 1913 and 1914, which he takes as proving that the gauge had been altered by 35 cm. in 1916.

But of course it proves nothing of the kind. If there had been no question of alteration of gauge, a gauge discharge table would have been made for 1919 in the usual way. It would then have been found that this table, when compared with the table made in 1912, showed a difference of gauge readings of between 30 and 40 cm. for any given discharge. This would then have been ascribed to silting. Sir William's new table proves one of two things, either (1) that the gauges have been altered and there is no silting, or (2) the gauges have not been altered and there has been considerable silting. The Commission has already decided that the gauge was not altered in 1916; it has, therefore, no difficulty in deciding that the latter of the two alternatives is the correct one.

There is no need to follow Sir William Willcocks any further into the details of his argument, for every one of his points can be explained equally well either by a change of gauge and no silt, or by an increase of silt and no change of gauge. Sir William Willcocks prefers to assume the former; the Commission has decided that the latter is the true explanation.

In paragraph 4 of Sir William Willcocks' discussion of this charge he controverts a statement made by Mr. Hurst before the London Committee; but this point has been discussed by Mr. Hurst on pages 109—111 of "Nile Control."

In his paragraph 5 Sir William Willcocks compares the gauge readings at Sennar and Roseires and concludes that as the Sennar gauge was altered by 35 cm. when it was rebuilt in 1916, the Roseires gauge must have been altered at the same time. It is impossible, however, to understand his presentation of the case. He finds the mean difference between the Roseires and Sennar gauges in 1908, 1912, 1913 and 1914 and compares it with the mean difference in 1915, 1916, 1919 and 1920. Why were the years 1909, 1910, 1911, 1917 and 1918 not used? Also why is 1915 put in the second period, for during that year the old gauge was still in use? The year 1916 is doubtful and should not be used in such a comparison. The only way to make a comparison of this nature is to plot the differences year by year, and when that is done it will be seen that there is no marked change in the difference between the gauges in 1916. Comparisons of this kind have been made by the Commission with all the gauges on the Blue Nile, from which it appears that if the Sennar gauge has been changed, they all have. The Commission cannot believe that every gauge has been changed, so this comparison is simply a further proof that the Sennar gauge has not been tampered with.

SIR WILLIAM WILLCOCKS' CHARGE No. 5.

The whole object of this charge appears to be to prove that after 1914 gauges on the Blue and White Niles were altered, so that from 1915 onwards the mean gauge readings, and in consequence the mean discharges, were considerably increased. Unfortunately Sir William Willcocks has been very vague in his statements and he gives no indication as to how he considers the falsifications have been carried out—whether by rebuilding the gauges or by altering the records—nor is it clear whether he considers that all the gauges on the rivers have been manipulated or only those whose data he uses; namely Malakal, Hillet Abbas, Roseires and Sennar.

His method of proof is extremely unsatisfactory as he only uses the data of nine single days chosen from four years to represent the period before 1914 and similar data for the period after 1914. It is not contended that he did this to obtain the result he required, but scientifically it is indefensible, for such a method always leaves unsettled the question of whether another result could not have been obtained by another choice of days. In all such investigations the method chosen should be one which makes use of as much as possible of the available data.

To follow Sir William Willcocks through his investigations point by point and to indicate where and why his method fails would be a large undertaking and probably one which would not carry conviction. It has, therefore, been considered best to make an entirely new investigation which will settle clearly the point in dispute and incidentally explain why Sir William Willcocks obtained his results.

Now the river gauges on the White Nile are very near to one another, and the slope of the river is extremely small. The mean readings of two neighbouring gauges will therefore follow one another fairly closely, particularly during the low river period. We will therefore examine the differences between the mean readings of neighbouring gauges for the period February to April of each year from 1907 to 1920. The year 1918 will, however, be neglected, as during this year an abnormal flood passed down the river during February, March and April, which acted as a disturbing factor.

Curve I., Fig. 1, shows the mean difference between the Taufiqiya and Malakal gauge readings for the period February to April of each year. These gauges are only 18 kilos. apart and the mean differences between their readings is remarkably constant, varying only by 4 cm. in eleven years. On the diagram a thick vertical line is drawn to show when, according to Sir William Willcocks, the change of gauge occurred. Now, if the Malakal gauge had been altered 30 cm. without a change in the Taufiqiya gauge the difference between the gauge readings would have increased by 30 cm. and the mean position of the points to the right of the vertical line would have been raised 30 cm. above the mean position of the points to the left of the line. On the diagram the distance between two horizontal lines represents 20 cm., therefore a break of 30 cm. would be shown by a raising of the points one and a half times the distance between the horizontal lines. No such change is shown on the diagram, from which we must conclude that if the Malakal gauge was altered, the Taufiqiya gauge was changed at the same time.

In Curve II. the Malakal and Kodok gauges have been treated in the same way and a similar conclusion can be drawn, *i.e.*, if the Malakal gauge has been altered the Kodok gauge has been altered also.

Similarly, Curve III. shows that the Kodok gauge cannot have been altered without a change in the Melut gauge.

An examination of the Curves I. to VIII. proves conclusively that if the Malakal gauge was altered in 1914 then all the gauges on the White Nile from Taufiqiya to Tamaniat were changed at the same time. This, however, does not prove that the gauges were not changed.

Curve IX. throws some light on the point. There we see that from 1913 to 1920 the mean difference in the Tamaniat and Khartum gauge readings *slowly and steadily* increased from year to year. Sir William Willcocks, in his introduction to his Charge 5, indicates that what first gave him the idea of the falsification of the White Nile gauges was noticing that in 1914 a gauge reading of 11.00 at Khartum corresponded to 11.00 on the Tamaniat gauge, while in 1920 a similar gauge reading at Khartum corresponded with 11.30 at Tamaniat. It will be noticed from Curve IX. that the difference between Tamaniat and Khartum was 0 in 1914 and 31 cm. in 1920, which confirms Sir William Willcocks' observation, but the curve itself disproves the conclusion he drew; for it shows clearly that the difference in the gauge readings had progressed steadily, which would not have been the case if the Tamaniat gauge itself had been lowered 30 cm.

The investigation so far has led to three important results :—

- (a) If any one gauge on the White Nile has been altered then all have been altered.
- (b) The change in the difference between the Tamaniat and Khartum gauges of 30 cm. between 1914 and 1920 has been substantiated, but
- (c) The change was not sudden, but gradual.

The change in the relationship between the Khartum and Tamaniat gauge readings is most important, but our investigation so far has not shown whether the change is due to a change in the levels at Khartum or at Tamaniat. To settle this point we must compare Khartum with other gauges. Unfortunately, this will necessitate taking into account the time taken for the water to pass between the gauges under investigation, and this always leads to difficulties, for this time is not constant but varies from year to year according as to whether the water level in the river is high or low. So far the gauges compared have been so near together that the time of travel has been too short to affect the comparison, but as it is now proposed to compare Malakal, Geteina and Wadi Halfa with Khartum, the time must be considered. For convenience in using the data available we shall compare the mean gauge readings at Khartum during the period February, March and April with the mean gauge readings at Malakal during January, February and March, with those at Geteina for February, March and April, and with those of Wadi Halfa from February 16th to May 15th inclusive. The mean gauge readings for these periods for each year from 1906 to 1920 have been taken for each station, and from these the differences Malakal-Khartum, Geteina-Khartum and Wadi Halfa-Khartum obtained.

On Curve X., Fig. 2, the difference Malakal-Khartum is plotted. It will be seen at once that the difference increases, very irregularly it is true, but a large part of the irregularity is due to the varying time of flow between Malakal and Khartum, which we have taken as being constant and equal to a month.

Curve XI., giving the relationship Geteina-Khartum, shows a similar progressive increase, but as these stations are relatively near to one another (Geteina is 90 kilos. from the junction of the Blue and White Niles) the curve is more regular.

The curve for Wadi Halfa-Khartum shows the same progressive increase in the difference between the gauge readings.

Curve XIII. has been obtained by taking the mean of the three separate curves and shows the progressive change most clearly. After this curve had been prepared the straight line was drawn through it to give an indication of the progressive change. In order to see whether the rate of change was the same for the individual curves a line was drawn through the centre of gravity of each of the three upper curves having the same slope as found from the mean curve. It will be seen at once that these lines fit the points remarkably well. The rate of change as obtained from the slope of these lines is 44 cm. in fourteen years. We have now seen that during the low water period the difference between the mean gauge readings at Khartum and three gauges representing the whole of the White Nile from Malakal to Khartum and the main Nile to Wadi Halfa slowly and steadily increases. An obvious and simple explanation of the phenomenon is that there has been a continuous improvement in the channel where the Blue Nile joins the White Nile just below the Khartum gauge, so that the Blue Nile now flows into the White Nile at a less difference of level than was formerly the case. Any one who has seen the sandbanks at the junction of the two Niles will be prepared to admit that such a change in the channel there is quite possible.

We are now in a position to explain Sir William Willcocks' results as far as gauge readings are concerned. He finds that the mean gauge readings at Tamaniat and Malakal compared with corresponding readings of Khartum are about 30 cm. higher after 1914 than before. He assumes that the gauges have been altered; we find that the difference is a natural consequence of the lowering of the water level at Khartum owing to an improvement in the channel where the Blue Nile joins the White Nile below Khartum. Whereas he assumed that the change took place during 1914 or 1915 we see that the change had been gradually in progress since 1906 at least; earlier observations have not been examined.

Sir William Willcocks finds no similar change in gauge readings when Wadi Halfa and Khartum are examined. This is simply the result of his faulty method of examination. By using data for nine days only in each period he not only gets an unrepresentative result, but he also increases largely errors due to the varying rates of travel of the water over the 1,533 kilos. between Khartum and Wadi Halfa. On the other hand, Curves X. and XII. show that the change in the relative level at Wadi Halfa has been as great as at Malakal.

Turning now to Sir William Willcocks' arguments based on discharges, he finds that for the period prior to 1914 the combined discharges for the Blue and White Niles compare favourably with those of the Main Nile as measured at Khartum and Wadi Halfa, but that there is a great difference afterwards.

Sir William Willcocks uses gauge discharge tables prepared prior to 1913. It is not surprising, therefore, that they give discharges for the gauges which agree during the earlier period, which is approximately the period covered by the observations on which the tables were based. But to apply these same gauge discharge tables for the period after 1914, without any corrections for scour or silt, is certainly not legitimate. In fact, it is easy to see that by the method he employs Sir William Willcocks gets no further evidence by using discharges than he had from the gauge readings alone. This may be seen as follows. The mean gauge readings at Khartum and Wadi Halfa used by Sir William were practically the same in the two periods; therefore, as he uses the same gauge-discharge table, the discharges for the two periods are the same.

Now the mean gauges at Malakal and Sennar were 35 and 46 cm. higher respectively in the later than in the earlier period. Therefore, using the same discharge tables, the discharges in the later period will be appreciably higher at both stations. In the earlier period there was practically no difference between the sum of the discharges at Malakal and Sennar and the discharge at Khartum; it is, therefore, a necessary consequence of the change in gauge readings that the difference should be large in the later period, for the discharge at Khartum remains the same, while the apparent discharges at both Sennar and Malakal have increased.

In this discussion we have not considered Sir William Willcocks' argument as it applies to the Blue Nile, for two reasons:—

- (a) There is practically no relationship to be expected between the gauge readings at Khartum and Roseires (or Sennar) during the low period; for the former depend on the level of the White Nile at the junction of the two rivers, while the latter depend approximately on the quantity of water flowing down the Blue Nile. Therefore a comparison of the differences between the gauge readings at Khartum, Roseires and Sennar, before and after 1914, cannot form the basis of any such discussion as that of Sir William Willcocks.
- (b) The Commission has already decided on other grounds that the Sennar gauge has not been tampered with in any way.

SIR WILLIAM WILLCOCKS' CHARGE No. 6.

The whole of the Aswan discharge data given in "Nile Control" for the period prior to 1902 has been based on a gauge-discharge curve drawn in November, 1919, by Mr. Hurst. The curve actually used is a composite curve built up of three independent parts, each of which must be discussed separately.

(a) *Gauge-Discharge Curve from 84.10 m. to 87.50 m.*—This curve was first prepared by the Public Works Ministry in about 1903, and is based on thirty-four float discharge observations made at Aswan in 1901 and 1902 by Messrs. Lanzoni and Gibson, with one extra discharge taken in 1900 by Mr. Gibson. The observations are well spaced over the portion above 84.50 m., but only one observation, that taken in 1900, was available

below this point. There can be no doubt that the curve drawn through the points is representative of the observations and may be taken as correctly giving the relationship between gauge readings and discharges in the low water periods of 1901 and 1902. A copy of this portion of the curve, with the observations on which it is based, is shown in Fig. 3.

(b) *Gauge-Discharge Curve from 87.50 m. to 92.20 m.*—This portion of the curve is based on current meter observations taken in 1918—1919, and was prepared in the following way. The discharges measured during the period when the river was rising were plotted against the gauges and a curve drawn through the points. Similarly, a second curve was obtained for the period of falling river. These curves did not vary from one another to any marked extent and it was considered that a single curve could be drawn between them to represent the river, whether rising or falling. The largest discrepancy between this mean curve and the individual curves is about 7 per cent., but the mean discrepancy is naturally much less, and the discrepancy on the rising river counterbalances the discrepancy on the falling river, so for the whole year no appreciable error results.

In order to meet the criticism that current meters give too high a discharge owing to turbulence of the water, especially in the flood, the Physical Department, although not agreeing that the need for any appreciable correction on this account had been proved, decided to make a compromise in order to be on the safe side. They therefore lowered the curve obtained as described above by amounts varying from 0 at a discharge of 2,000 cubic metres per second to 10 per cent. at a discharge of 10,000 cubic metres per second. The curve thus reduced then became the final gauge-discharge curve used for converting gauge readings into discharges.

(c) *Gauge-Discharge Curve from 92.20 m. to 93.50 m.*—This portion of the curve is a simple extrapolation of the upper part of the final curve described in the last section. The extrapolation appears satisfactory, but, of course, it has not the value of a curve based on measurements.

The curves for the three portions described run very well into one another and a satisfactory gauge-discharge curve from 84.10 to 93.50 results.

In 1893 Sir William Willcocks prepared a gauge-discharge curve for the Nile as a whole, north of Aswan. He describes its preparation as follows in "Egyptian Irrigation," second edition, p. 41: "Discharge sites having been chosen for the "Aswan and Cairo gauges of the Nile, a continuous series of surface-velocity "observations, cross-sections and slope measurements were made by me during 1892 "and 1893 and the resulting discharges recorded. Curves of discharge were drawn "and referred to the gauges of twenty years and modified until, finally, a curve was "found which suited any year whether it were a maximum or a minimum."

From this curve Sir William Willcocks prepared his Aswan discharge table, which is reproduced on p. 45 of his "Egyptian Irrigation," where it is described as "Discharge Table of the Aswan Gauge which may be used approximately for any "gauge on the Nile north of Aswan with its zero at mean low-water level."

The Commission has examined an original diagram signed and dated by Sir William Willcocks on 16/12/93, which gives his gauge-discharge curve and shows the observations on which it is based. The curve appears to be a good representation of the observations so far as they extend.

The position, then, is that the Public Works Ministry in preparing "Nile Control" have used a gauge-discharge curve for Aswan which is different from that compiled by Sir William Willcocks in 1893: it is natural, therefore, that the discharges determined from the gauge readings should be different.

In comparing the two curves one is met with the difficulty that they vary differently in different parts, and the reasons for the differences are not the same in the various parts. The best method of investigating the problem is to give a table showing the gauge readings for various discharges according to curves.

I.	II.	III.	IV.	V.	VI.
Discharge in m. ³ per sec.	Gauge, Willcocks.	Gauge, P.W.M., uncorrected for turbulence.	Difference II.—III.	Gauge, P.W.M., corrected for turbulence.	Difference II.—V.
500	85.22	84.94	28	84.94	28
1,000	86.34	86.00	34	86.00	34
1,500	87.16	86.85	31	86.85	31
2,000	87.84	87.53	31	87.53	31
3,000	88.90	88.53	37	88.63	27
4,000	89.77	89.37	40	89.58	19
5,000	90.43	90.11	32	90.39	4
6,000	91.10	90.77	33	91.09	1
7,000	91.70	91.34	36	91.68	2
8,000	92.20	91.83	37	92.20	0
9,000	92.68	92.28	40	92.63	5
10,000	93.08			93.04	4
11,000	93.43			93.38	5

Column I. of the above table contains the discharges considered.

Column II. gives the gauge readings according to Sir William Willcocks' curve for the discharges given in Column I.

Column III. gives the corresponding gauge readings from the Public Works Ministry's curve *before it was corrected for a possible turbulence*.

Column IV. gives the difference between Columns II. and III.

It will be noticed at once that the difference between the two curves is wonderfully steady, varying from 28 cm. with a discharge of 500 m.³ per second to 40 cm. with a discharge of 9,000 m.³ per second. Sir William Willcocks has put forward this fact as being proof that the Public Works Ministry's discharge table was a copy of his, but lowered by 30 cm., and that it was not based on new observations. As the Commission has examined the actual observations used as the foundation of both curves and found that they were entirely different this statement of Sir William Willcocks' is clearly wrong.

The obvious and simple explanation is that both curves are good gauge-discharge curves, but that they refer to different conditions of the river. A difference of erosion of between 30 and 40 cm. is sufficient to explain the whole difference.

The Public Works Ministry's curve was, however, corrected at the higher discharges as already explained, to allow for a possible turbulence effect. In Column V. of the above table, the corrected values have been given and in Column VI. the difference between them and Sir William Willcocks' values. It will be seen that above 2,000 cubic metres per second (at which discharge the corrections commenced) the correction causes the Public Works Ministry's curve and Sir William's to approach and above 5,000 cubic metres a second they become practically the same. Thus there is practical agreement between the discharges determined by Sir William Willcocks and by the Ministry during the flood season.

We have now to consider the portion of the two curves below a gauge reading of 85 m.

The two curves give the following values :—

Gauge.	Discharges.		
	Sir Wm. Willcocks.	P.W.M.	Sir Wm. Willcocks' curve corrected for 30 cm. silt.
I.	II.	III.	IV.
85.00	410	524	530
84.90	380	484	490
84.80	350	448	450
84.70	320	416	410
84.60	290	388	380
84.50	260	364	350
84.40	230	344	320
		16	
84.30	210	328	290
		12	
84.20	190	316	260
		8	
84.10	170	308	230
		4	
		0	

In Columns II. and III. are given the discharges from the two curves respectively corresponding to the gauge readings contained in Column I. It will be seen that there is considerable difference; but this is mainly due to the 30 cm. of erosion which we have found to affect the two curves throughout their whole extent. If an erosion of 30 cm. is applied to Sir William Willcocks' curve, we obtain the discharges contained in Column IV., which agree closely with the Public Works' values down to a gauge reading of 84.60. Below this gauge the discharges again depart appreciably, and it is understood that it is mainly to this part of the curve that Sir William Willcocks objects. In the public hearings Sir William Willcocks explained that he considered the objection to the lower part of the Public Works' curve was that the discharges decreased so slowly with decreasing gauges that below a gauge reading of about 83.90 the discharge would be constant at about 300 cubic metres a second, quite independently of the gauge reading. The reply of the Public Works Ministry to this was that their curve had been drawn to fit actual observations, and it is quite impossible, without observations with lower gauge readings, to say what the river discharge would be at lower gauges. The Commission considers that this answer really meets the case, and it is only when observations have been made with less water in the river than has ever occurred that the point can be decided, one way or the other. We have now seen that there are two reliable gauge-discharge curves for Aswan, one prepared by the Public Works Ministry and one by Sir William, but that they differ because they apply to different states of erosion of the river bed. The question naturally arises, which curve should be used in determining the discharge in the river for the period before we have sluice discharges from which the erosion can be calculated. The reply of the Commission is that neither curve would give absolute values, and that either curve may be used if it is constantly borne in mind that the discharges obtained are only approximate. Naturally the Public Works Ministry have used the curve prepared by themselves, not, as suggested by Sir William Willcocks, because it gave higher discharges than those given by his curve, but simply because they naturally put more reliance in a curve which they have themselves prepared from observations made at Aswan than in an old curve based on observations about which they know very little, and made at many different places on the river from Cairo to Aswan. It may be mentioned that the discrepancy between discharges for the whole year obtained by the use of the two curves is only of the order of 10 per cent.

COLONEL KENNEDY'S CHARGES Nos. 1, 2, 3, 4 AND 5.

Colonel Kennedy's first five charges raise no new technical points.

COLONEL KENNEDY'S CHARGE No. 6.

The diagram, signed by Sir Murdoch MacDonald on May 20th, 1917, and alleged by Colonel Kennedy to be a falsification, consists of two parts :—

Diagram I. showing—

- (a) Discharges of the Blue Nile in m.³ per second in two extremely low years (1908 and 1914) during the critical period, December to April.
- (b) Discharges required for different areas under cultivation in the Gezira.

Diagram II. showing—

Total volume discharged by the Blue Nile at Sennar between February 1st and April 15th for the years 1907—16.

These diagrams were made by Mr. Hurst in the following way :—

Diagram I.—The discharge for Sennar from about December 19th, 1913, to April 19th, 1914, is given by a smooth curve drawn through measured discharges plotted against their dates. These discharges were measured at Soba, near Khartum, and at Wad Medani. Mr. Hurst has given reasons to show that they are approximately the discharges at Sennar. This question is discussed in the Computations Book for the Blue Nile Gezira Scheme, and also in "Nile Control," pp. 110 and 111.

The discharge for Sennar in 1908 from January 7th to April 16th was obtained from a gauge-discharge table based on discharges at Sennar, and reduced to fit approximately the few observations of 1908.

Both these time-discharge curves are smoothed, and do not follow the daily variations of discharge.

The lines showing the water requirements of different cultivable areas are based on figures supplied by the Sudan Plantations Syndicate. The water requirements finally adopted in the Computations Book and "Nile Control" after discussion of information supplied by the Sudan Agricultural Department, and the quantities of water actually pumped on the experimental farms, are very similar to those in this diagram.

Diagram II.—The volumes of water given in this diagram were obtained directly from the actual measured discharges for 1914, the lowest year, and in the other years by the aid of a gauge-discharge table, which was checked against the measured discharges in the next lowest years, 1908 and 1913.

In the higher years some errors occurred which were corrected in later publications.

The statement at the side of the diagram that the year 1914 was so exceptionally low on the Main Nile that nothing like it had been recorded in the last 150 years has been criticised by Sir William Willcocks.

The explanation of this, as given by Mr. Hurst, is that the wording is rather loose, and the year 1914 should have been the year 1913—14, as he was thinking of the flood and period following immediately. There are no discharge records which go back 150 years. There are, however, gauge records on the Main Nile for the flood maximum at Roda, near Cairo, which go back more than 150 years, detailed gauge records for fifty years back at Aswan and Roda, and for thirty years at Halfa. These show that the levels for the flood and period up to about the middle of March in 1913—14 undoubtedly were the lowest of which there is authentic record.

In the absence of any amplification of Colonel Kennedy's charge, which would give an idea of the grounds on which he bases it, the Commission can do no more than state the above facts and add that the diagram was prepared in the usual way, and that they can find no evidence of any falsification or desire to mislead.

COLONEL KENNEDY'S CHARGE No. 7.

Gauge readings at Khartum are available from May, 1899, but during the flood of 1900 the gauge was rebuilt. It was then found that the readings on the new gauge were 22 cm. higher than on the old gauge. To make a homogeneous series of observations the readings taken on the old gauge were increased by 22 cm., bringing them into line with the new gauge.

A few years ago, owing to remarks made by Colonel Kennedy, a doubt arose as to whether the 22 cm. ought not to have been subtracted instead of being added to the early readings. The original records could not then be found, but Mr. Hurst was able, by a statistical investigation, to show that the correction applied was probably correct. It now appears that the original gauge register was in the personal possession of Colonel Kennedy, but when the Commission examined this book it was clear that the correction had been correctly applied, for on every page of the book containing readings subsequent to January 1st, 1900, was entered in red ink "22 cm. are to be deducted in comparison with last year." Many of the entries during this period were initialled by Colonel Kennedy who was then in charge of the gauge at Khartum, thus indicating that he confirmed the accuracy of the correction. Adding 22 cm. to the readings of the old gauge is obviously the same as deducting 22 cm. from the readings of the new gauge.

After the public hearings Colonel Kennedy saw the Commission on other matters, and incidentally remarked that the error in the gauge at Khartum was not due, as supposed, to a wrong transfer of the level from one gauge to the other, but that the zeros were correctly transferred, and it was only in the upper part of the scale that there were differences between the two gauges. He stated that the scale of the new gauge was correct from zero, but the mason in marking the old gauge had cut the marks wrongly. The error was, therefore, in the old gauge and was cumulative from the zero upwards and was 20 cm. at the higher levels. The Commission asked Colonel Kennedy to put his explanation into writing so that it may be investigated further by the Public Works Ministry. This, no doubt, will be done if Colonel Kennedy complies with the wishes of the Commission. Having heard this explanation which, apparently, was known to no one but Colonel Kennedy himself, and was certainly not on record in the files of the Irrigation Service, either in Khartum or Cairo, the Commission cannot understand why Colonel Kennedy wrote in his charge, "I accuse Sir Murdoch MacDonald of *deliberately* publishing false readings of Khartum Nilometer for the "record low summer supply year, viz., 1900." (The word "*deliberately*" was double-underlined in the original.)

Colonel Kennedy knew that Sir Murdoch MacDonald had no original records of the Khartum gauge, the original notebook being in Colonel Kennedy's own charge, and Colonel Kennedy had not explained to Sir Murdoch MacDonald how the gauge was in error. It is, therefore, clear that Colonel Kennedy knew quite well that Sir Murdoch MacDonald could not have deliberately published false readings.

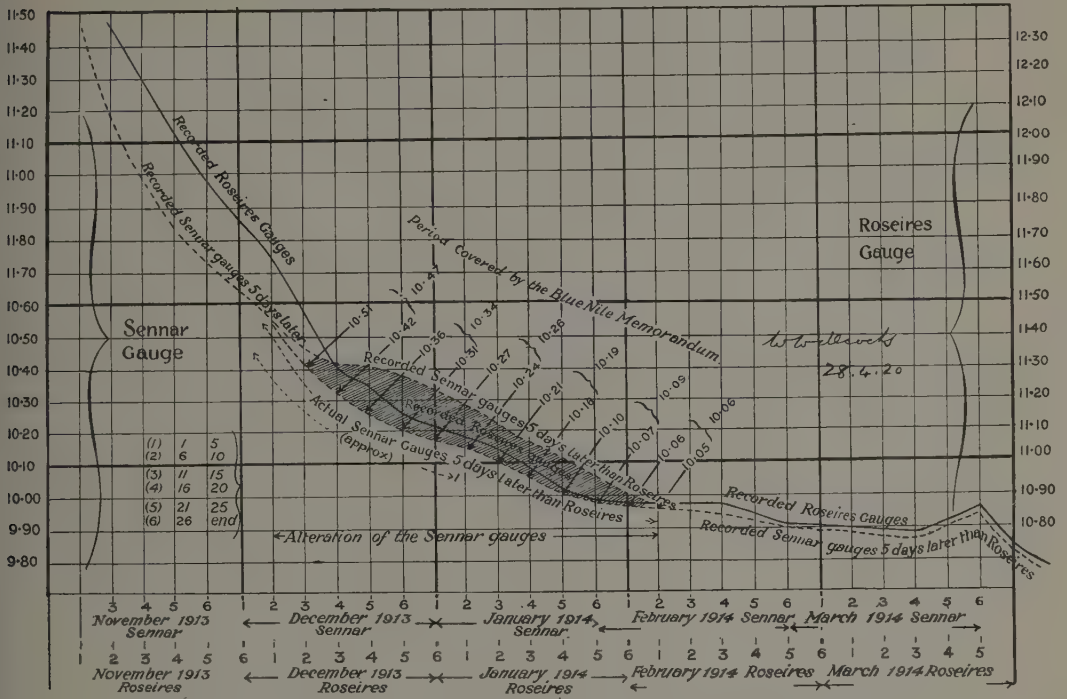
(Signed) F. ST. J. GEBBIE.
H. T. CORY.
G. C. SIMPSON.

August 25th, 1920.

DIAGRAM A.

DIAGRAM OF THE SENNAR GAUGES

from November 1st, 1913, to the end of March, 1914, showing the alteration.

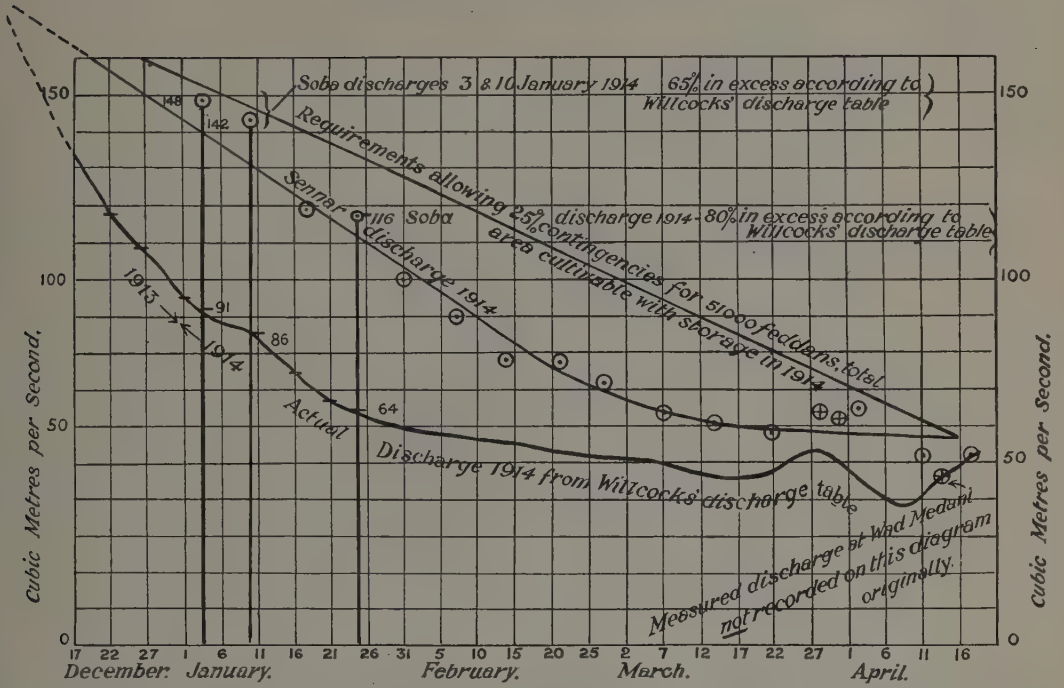


N.B.—In November and the first half of December the water travels from Roseires to Sennar in less than five days, hence the greater differences.

(Signed) W. WILLCOCKS.
28/4/20.

DIAGRAM B.

SENNAR DISCHARGE, 1914.



⊙ ⊕ = Actual discharges observed at Soba and Wad Medani. The experience of 1913 shows that at the low levels of the river the discharges at Sennar and Soba are the same on the same date.

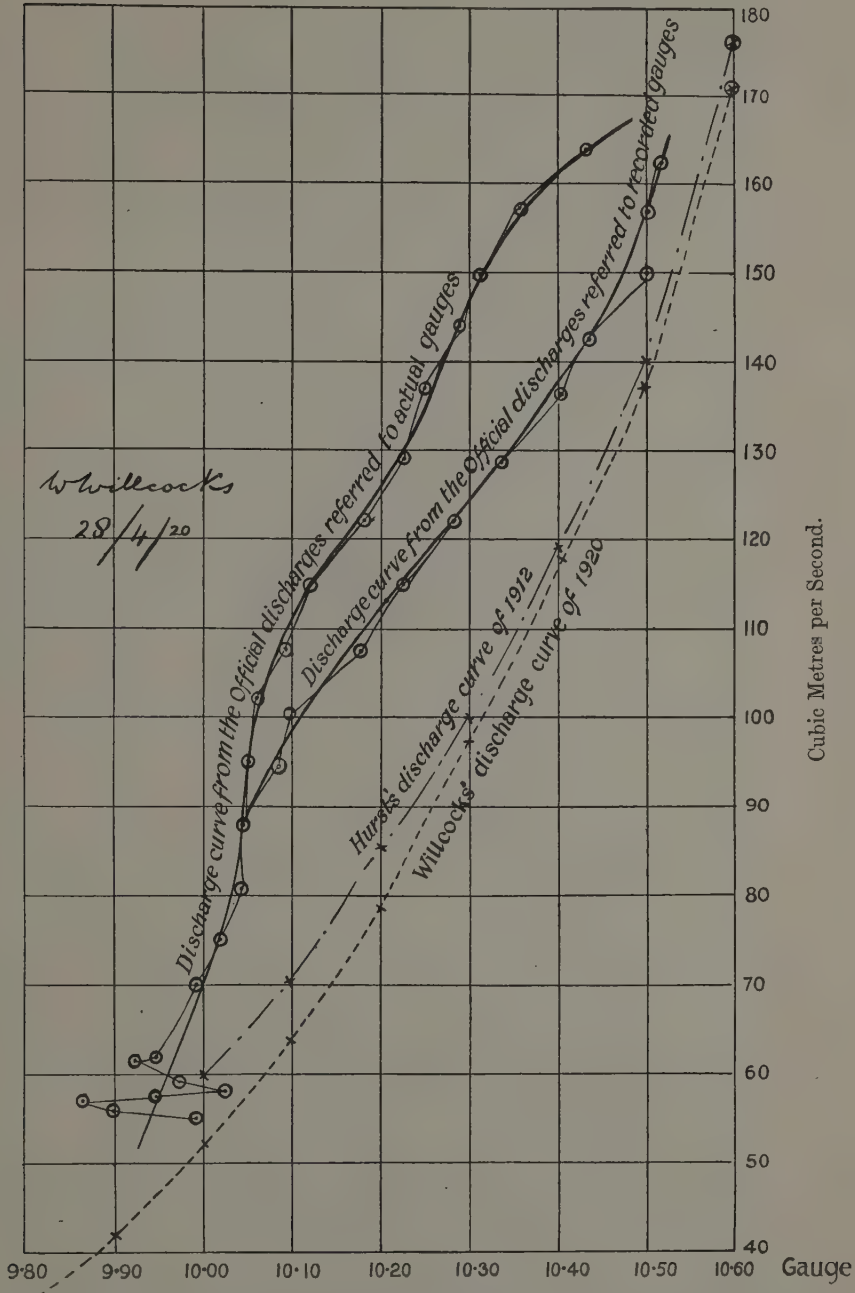
(Signed) H. E. HURST.
5/6/18.

Additions by Sir William Willcocks, May, 1920.

DIAGRAM C.

SENNAR DISCHARGE DIAGRAM

from December 17th, 1913, to March 16th, 1914, from the Official Diagram dated 20/5/17.



N.B.—It is physically impossible for Discharge Curves to be **out** curves. They can only be in curves like Hurst's and Willcocks'.

(Signed) W. WILLCOCKS.
28/4/20.

FIGURE 1.

WHITE NILE

GAUGE DIFFERENCES FEB. MAR. APRIL.

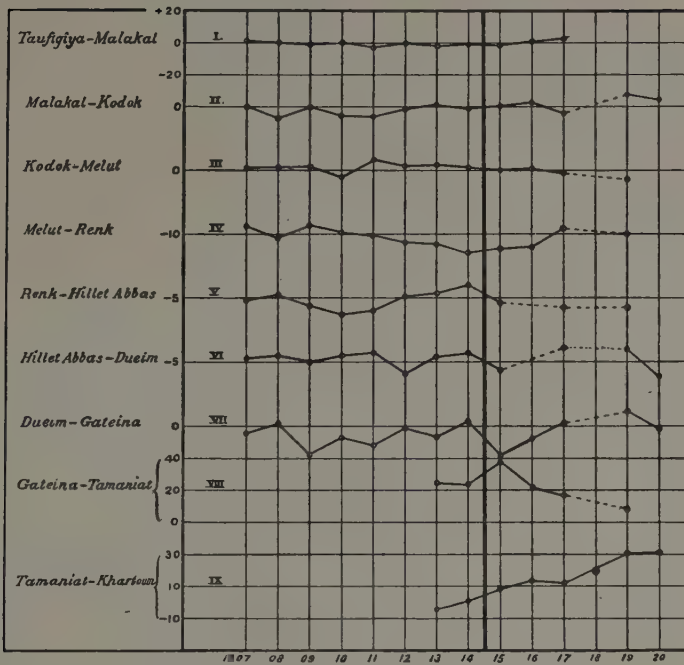


FIGURE 2.

WHITE & MAIN NILES

GAUGE DIFFERENCES

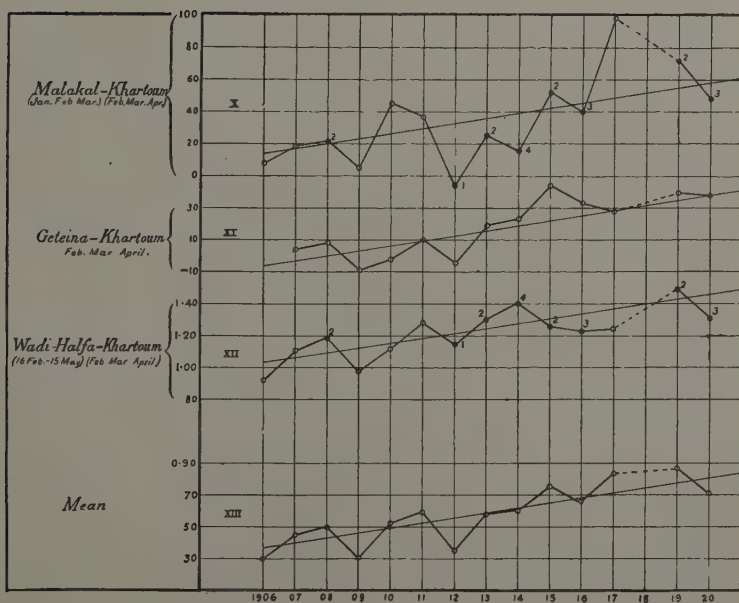
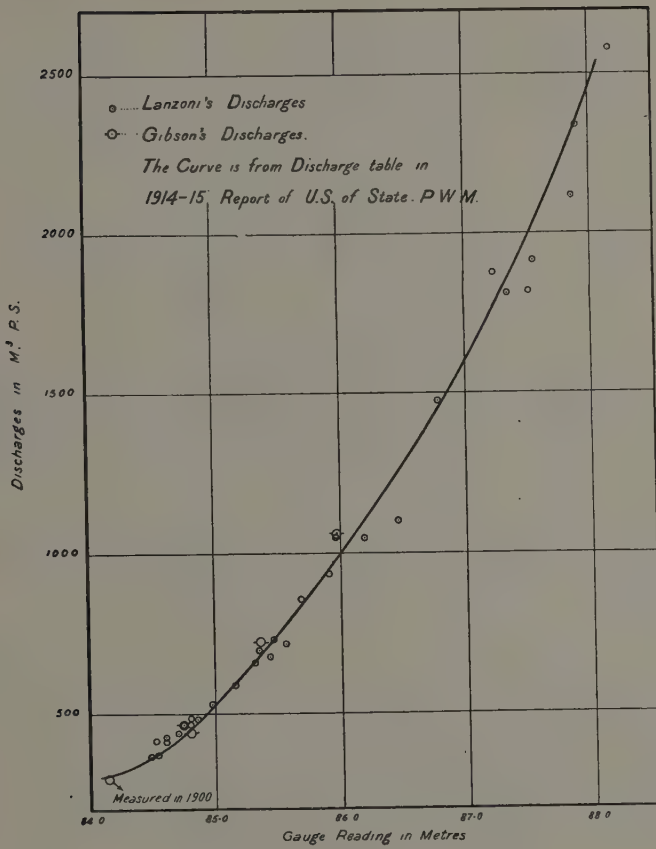


FIGURE 3.

FLOAT OBSERVATIONS TAKEN AT SHEMA, ASWAN
SEASON 1901-02.



CHAPTER III.

Report on First Term of Reference from the Engineering Standpoint.

THE projects on which the Commission is asked to report are fully described in Volume I. of the publication called "Nile Control," and are :—

1. The White Nile Dam (pp. 43—76).
2. Gezira Irrigation Scheme and Blue Nile (Sennar) Dam (pp. 81—116).
3. The Nag Hamadi Barrage (p. 119).
4. The Upper Blue Nile Dam (p. 123).
5. The Sudd Region and Lake Albert (pp. 127—134).

THE WHITE NILE DAM.

It is admitted by all that, even if there is no further extension of cultivation, Egypt must have more summer water, and this extra supply can only be provided by the construction of a reservoir or reservoirs on the Nile or by prevention of avoidable waste of water. Egypt must have this additional supply as soon as possible, and the construction of a reservoir will be the quickest means of providing it.

It is desirable, if not essential, that the reservoir should be as near Egypt as possible ; but it cannot be constructed north of Khartum because it would be necessary to commence filling the reservoir before the end of the flood season, because Aswan already takes practically all the flood water which is free from silt, and it would rapidly silt up owing to the heavy silt contents of the Blue Nile in flood.

The reservoir must therefore be constructed on the White Nile, the waters of which are free, or practically free, from silt at all seasons, at some point south of Khartum. Several sites have been suggested for such a reservoir, and the Commission, for reasons given on page 45 of "Nile Control," agrees with the Public Works Ministry that the most suitable site is that at Gebel Aulia. This is not an ideal site for a reservoir, and it can never be an economical one, as the losses by evaporation and percolation must always be heavy, amounting almost to the volume by which the summer flow below the reservoir will be increased by its existence ; but it must not be overlooked that most of the water so lost would have passed into the sea if the reservoir had not existed, and thus the real loss is not so great as it appears. Taking all requirements into consideration, it seems to be the best site available. It will afford Egypt a certain degree of flood protection and the necessary storage for the additional summer water immediately required. This reservoir will not become superfluous when further works are undertaken to provide Egypt with the water which will be required when the salt lands in the north of the Delta are reclaimed, as a dam or regulator near the junction of the Blue and White Niles is a necessary part of any project for completely controlling the supply in the Nile.

The dam is to be a solid masonry structure, with the necessary sluices, from Gebel Aulia westwards to the high land on that side of the river, a distance of 5·030 kilometres. This part of the dam is designed on the same lines as the Sennar Dam

and the foundations are in good sandstone throughout. From Gebel Aulia to the high land on the east, the dam is to consist of an earthen bank with a masonry core wall. The length of this part of the dam is 1.650 kilometres, and, as the maximum head of water against the bank will never exceed one metre, this bank will be perfectly safe.

The construction of this dam will entail the flooding out of a number of villages and of a considerable area of land now cultivated on the annual flood of the river; but, with the exception of three, these villages are collections of straw huts. The more important villages can all be rebuilt on high land not far from their present sites. The less important villages will have to be moved back to a level above the flood protection contour of the reservoir.

The cultivated area which will be flooded out varies from 17,000 to 107,000 feddans, this large variation being due to the fluctuating nature of the annual flood. After the construction of the reservoir the conditions will be improved, as described on pages 51 and 74 of "Nile Control." The calculations of the volumes impounded in the reservoir at storage and flood protection levels have been carefully made, and the Commission accepts them as substantially correct. The estimates of losses by evaporation and percolation are on the safe side.

Dr. Crispin, the present Director of Medical Services in the Sudan Government, has assured the Commission that he is satisfied that the health conditions at Khartum will not be prejudicially affected by the construction of this reservoir, and the Commission recommends that its construction be undertaken forthwith.

THE GEZIRA IRRIGATION SCHEME AND BLUE NILE (SENNAR) DAM.

This project, as submitted to the Commission, provides for the irrigation of 300,000 feddans of land in the districts of Sennar, Wad Medani, Managil, Messelamia and Kamlin. This area can be raised to 1,000,000 feddans when the increase in population and the consequent demand for increase of cultivation renders this necessary, but this increase will entail the construction of the Upper Blue Nile Dam referred to later.

↓ Of the 300,000 feddans, one-third will annually be under cotton, one-third under green crops and one-third fallow.

The dam has been designed in accordance with usual engineering practice and the foundations are in sound rock.

The waterway, provided by sluices and spillways, is ample, being capable of passing a flood 25 per cent. in excess of the maximum known flood without dangerous afflux. The storage in the reservoir is sufficient to provide for the area of cultivation contemplated during the period in which the Sudan cannot be permitted to draw upon the natural flow in the river, i.e., from about the middle of January till the middle of April, and to supply drinking water to the tract from the middle of April till the flood commences in July. In other words, the storage is sufficient to supply water for drinking and irrigation purposes between the dates mentioned even if there were no flow at all in the river throughout this period.

The reservoir can be filled with water which is now, and must always be, allowed to flow to waste into the sea. The reservoir can therefore be filled without withdrawing from the river one drop of water to which Egypt is entitled, nor does it rob Egypt of silt. It is clear, therefore, that the proposed scheme cannot adversely affect Egypt.

Fears have been expressed that this reservoir may silt up in a short time, but the Commission is satisfied that, if the procedure described on pages 87 and 88 of "Nile Control" is adhered to, the danger of silting is remote, and any silting which may occur on the berms will be quite negligible in comparison with the total capacity of the reservoir. In calculating the net supply available in the reservoir, ample provision has been made for loss by evaporation.

CANAL AND DISTRIBUTORY SYSTEM.

The head regulation is designed to pass enough water for an eventual area of 1,000,000 feddans ; but the canal is to be excavated to carry enough water for 300,000 feddans only. It is not so stated in the report, but the Commission assumes that all other masonry works on the main canal will be constructed with sufficient waterway to pass this volume of water required for 1,000,000 feddans, or, if not, that they will be built in such a way as to admit of easy enlargement when required. The allowance of water at canal head per feddan of gross area commanded is based on the experience gained in past years on the experimental farms at Taiyaba and Barakat. This allowance is accepted as sufficient by the officers of the Sudan Agricultural Department and the Sudan Plantations Syndicate, and the Commission agrees that it is satisfactory.

The estimates of losses in the main Gezira Canal and its branches are somewhat higher than those usually adopted in America and India ; while that for distributaries is considerably lower. But, as these estimates are based on experience gained in Egypt on canals more or less similar to these now proposed, the Commission makes no suggestion that they should be modified. The canal may eventually be enlarged, and it is suggested that the actual transmission losses on the canal, as now to be constructed, should be carefully measured. The information so obtained should be made use of in designing the enlarged canal.

The Commission considers that the project is an eminently satisfactory one and should be completed with the least possible delay. The Commission feared that lack of population might retard development, but the officials of the Sudan Government and of the Sudan Plantations Syndicate, whose local knowledge is very much greater than that of the Commission, are quite certain that all the labour required to work up to their programme of development can be obtained and we accept their opinion.

THE NAG HAMADI BARRAGE.

The Commission considers that, even if none of the other projects described in " Nile Control " are carried out, this Barrage is a necessity to convert an area of about 500,000 feddans in Egypt from basin to perennial irrigation. This necessity alone is quite sufficient to justify the construction of this Barrage.

UPPER BLUE NILE DAM.

The Commission considers that a work of this nature is essential for the full development of the Gezira Irrigation project and also in the interests of Egypt. The information available, although very meagre, indicates that such a work would be feasible from an engineering point of view, and we recommend that further investigations in the upper catchment area of the Blue Nile be undertaken immediately and prosecuted vigorously.

THE SUDD REGION AND LAKE ALBERT DAM.

The Commission also considers a project of this nature necessary for the development of irrigation in Egypt to its fullest extent, but in this case also the information at our disposal is not sufficient for us to give anything but a very general opinion on the project.

If the proposed cut from Bor (or possibly from a point as far south as Rejaf) to the Sobat mouth is not impossible on financial or engineering grounds, it would prove probably the most satisfactory solution of the difficulty of getting water from Lake Albert to the White Nile without incurring the enormous losses which do now, and must always, occur in the Sudd region.

This cut, in connection with a reservoir on Lake Albert, would considerably increase the supply of water for Egypt and the Sudan. No part of the line of the proposed cut has yet been surveyed, and it is understood that part of the country through which it would pass has not even been explored. It will take several years to collect the data necessary to arrive at a decision as to whether the proposed cut and Lake Albert Dam are possible or not, and the Commission recommends that surveys should be commenced as soon as possible.

It has been suggested that an additional supply of water might be obtained from the Bahr el Ghazal, and the Commission considers that this possibility might perhaps be further investigated after the surveys for the Bor Cut and Lake Albert Dam have been completed.

The Commission does not consider it is worth while spending time or money investigating proposals for the construction of reservoirs in the Sudd region.

The estimates of the water requirements of Egypt, when irrigation has been developed to its fullest extent, have been prepared with care and in great detail ; but the Commission is of opinion that the estimate prepared by Mr. Hurst and accepted by the Public Works Ministry is rather on the low side. Mr. Victor Mosséri, a recognised expert on agricultural matters and practical irrigation, has favoured the Commission with an estimate he has prepared. This estimate is based on different areas of the various crops and on different rotations to those adopted by Mr. Hurst ; but the total volume of water required, according to this estimate, agrees exactly with that arrived at by Messrs. Molesworth and Yennidunia, and the Commission recommends that this figure, viz., 58 milliards of cubic metres, should be tentatively accepted as Egypt's ultimate water requirements.

(Signed) F. ST. J. GEBBIE.
H. T. CORY.
G. C. SIMPSON.

August 25th, 1920.

CHAPTER IV. (SECTION ONE.)

**Report on Second and Third Terms of Reference by the
President and Dr. Simpson.**

THE second and third terms of reference are :—

(A) To report upon the propriety of the manner in which, as a result of these projects, the increased supply of available water provided by them will be allocated at each stage of development between Egypt and the Sudan.

(B) To advise as to the apportionment of the cost of the proposed works and of this inquiry as between Egypt and the Sudan.

With regard to Mr. Cory's report, we feel that, while his findings may be theoretically correct, it is impossible, on financial and other points, to apply them in present circumstances.

We regard it as indisputable that Egypt has by right of long use established a claim to a supply of water sufficient to irrigate an area equal to the largest area which has been irrigated in any single year since the Aswan Dam in its present form was completed, and that Egypt has an established claim to receive this water at the particular seasons when it is required. The year in which the largest area was irrigated appears to be 1916—17, when an area of 5,400,000 feddans (in round figures) was under cultivation.

The Sudan has also acquired a right to irrigation water for a certain area ; but we have not been able to obtain sufficient data to enable us to determine what this area is. It is, however, very small in comparison with Egypt's established claim.

We regret we are unable to decide precisely what proportion of the increased supply of available water which will be provided by the projects should be allocated to Egypt and the Sudan respectively, because it has been impossible to obtain sufficient data on which to base any reliable forecast of the probable rate of increase of irrigation in the Sudan. But after consulting Sir Murdoch MacDonald and officials of the Sudan we submit the following suggestions as a workable solution of the problem which should be acceptable both to Egypt and the Sudan.

(i.) The Sudan Government to pay for the Sennar Dam and the water derived from it to be used by the Sudan only. If, however, the stored water unused on April 15th in each year is given to Egypt, then the cost of providing, by pumping or other agreed method, drinking water for the cultivators on the Gezira and their live stock will be borne by Egypt.

(ii.) The White Nile Dam (Gebel Aulia) to be paid for by the Egyptian Government, and the water derived from it to be used for Egypt. As the reservoir will cause material damage south of Gebel Aulia, the Egyptian Government will pay or provide full compensation, in cash or kind, for such damage. As the effect of the dam will be to injure to some extent the basin and other systems of flood irrigation north of Khartum in the Provinces of Khartum, Berber, Dongola and Halfa, so much water as shall permit 80,000 feddans of

summer crops in these provinces to be irrigated by pumps shall, as compensation, be appropriated every year from the Nile after the Gebel Aulia Dam is built.

(iii.) The Sudan Government already has the right to pump water without restriction between July 15th and March 1st and the right to irrigate 20,000 feddans of summer crops, and is availing itself of the latter right partly on the Blue Nile and partly on the Main Nile. After the construction of the Sennar Dam the latter pumping right will no longer be exercised on the Blue Nile for the land now irrigated within the area of the Gezira scheme. The Sudan Government may therefore use her right to withdraw water from the Nile for the irrigation of 20,000 feddans of summer crops in such other areas dependent on the Nile as she may find suitable. Thus, after the construction of the Sennar and Gebel Aulia Dams the Sudan will have the right to irrigate by pumps from the Nile 80,000 feddans of summer crops north of Khartum, in the Provinces of Khartum, Berber, Dongola and Halfa, and 20,000 feddans anywhere else in the Nile basin as well as the free flow system in the Gezira as described in para. (iv.) below.

(iv.) The Gezira scheme is so designed that 300,000 feddans can be developed without using any water naturally flowing in the Blue Nile after January 18th in any year. In most years Egypt can spare water from the Nile after this date and the Gezira scheme need not draw on the storage in the Sennar reservoir till later than January 18th. The area under cultivation may therefore be increased beyond 300,000 feddans provided the cultivators are prepared to suffer an occasional shortage in the event of the occurrence of a very low year. The Sudan may therefore be permitted to withdraw water from the Blue Nile after January 18th to such a date as corresponds to the first use of storage water at Aswan to supplement a shortage in the natural river supply for Egypt.

The eventual development of the Gezira to a cultivated area of 1,000,000 feddans is contingent on the construction of the Upper Blue Nile Dam. This dam will be built by Egypt and paid for by her in the first place. Egypt will use all the water so provided at the beginning, but the waters from the Upper Blue Nile Dam will, as and when required for the development of the Gezira, be allocated in increasing quantity to the Sudan, who shall then pay a share of the cost of the dam in proportion to the water she receives from it. The Sudan may, instead of using such water from the Blue Nile, use the same quantity or a less amount by pumping from the White Nile for such period as she may wish.

(v.) At present it is difficult to form any reliable estimate of the relative proportions required by Egypt and the Sudan of the water to be furnished by the construction of the other works contemplated in "Nile Control," but it is recognised that when the time arrives the Sudan shall share in the water derived from these new sources. The Sudan Government will then be called upon to pay an equitable share of the cost of the new works proportionate to the volume of water used.

(vi.) As differences of opinion may arise in regard to the interpretation or application in practice of the above suggestions, the Commission recommends that a Board, consisting of two members representing Egypt and the Sudan respectively, with an independent chairman, should be appointed and all differences of opinion referred to it.

We are of opinion that Egypt should pay two-thirds of the expenses of the Commission and Sudan one-third.

(Signed) F. ST. J. GEBBIE.
G. C. SIMPSON.

CHAPTER IV. (SECTION TWO.)

Report on Second and Third Terms of Reference by Mr. Cory.

ALLOCATION OF WATER.

My colleagues on the Commission hold that it is not possible to offer any advice as to the allocation of water either for the immediate or distant future owing to lack of data, and endorse the Ministry of Public Works' proposals without qualification.

It is obvious that the proposal to give the Sudan the stored Blue Nile water and Egypt the stored White Nile water seems, on the face of it, a simple and practical one in view of the fact that the Sudan is to pay for Makwar and Egypt for Gebel Aulia, and that the Sudan is financially not in a position now to share in the cost of Gebel Aulia, even if it wished to. After a careful examination of the data, and for reasons explained later in this report, I desire to point out that in my opinion there is a danger of the Sudan losing now a good opportunity of further development in the near future without prejudice to Egypt, unless an agreement is made between the two Governments admitting the right of the Sudan to use Gebel Aulia water not required by Egypt when able to pay for it.

There are several features of great importance in connection with water allocation in this case.

The first is that England is much in the position of a guardian to two wards and therefore is in a situation of peculiar responsibility. This is specially true as regards the interests of the Sudanese, who, in the present state of development of the country, cannot voice their own needs. The Government should, therefore, safeguard their interests by endeavouring to insure that the inhabitants may not ultimately suffer through insufficient attention being paid to the full possibilities of any projects.

The second is that while the Makwar and Gebel Aulia Dams are already under construction, the Upper Blue Nile storage is only a plan and, owing to political contingencies, may be long delayed and even never eventuate, while the financial and engineering practicability of the Sudd Channel (and the necessarily subsequent storages in Lakes Albert and Victoria) are yet to be determined. Hence the division of the unappropriated waters storable behind the Gebel Aulia and Makwar Dams is of at least the most immediate importance.

The third is that Egypt is a wealthy country and the Sudan poor. It is understood that the Makwar Dam and Gezira canalisation will exhaust the Sudan's present financial resources for irrigation development. The Makwar Dam is primarily a diversion weir and will create but .47 milliards net storage; about 90 per cent. of its probable cost of £3,000,000, or, say, £2,700,000, is chargeable to diversion (raising water to the main canal intake) and only 10 per cent. chargeable to storage—say, £300,000. This £2,700,000 for a *diversion* structure will suffice for diverting water for all the Gezira, but is an expenditure which has to be all made at the very beginning. Until the Sudan recovers from such a severe financial strain and, also, until the 300,000 feddans for which the .47 milliards storage will ordinarily suffice are well on towards full cultivation, the Sudan is not in a position to join in financing more storage works, nor is it to its interest to do so. Egypt, on the other hand, is sorely in need of

additional storage and wants it at once. Here, then, are two parties inexorably joined in a partnership of a common natural resource of vast importance to each with different interests at the moment.

The ethics of the case seem to be that neither party can properly or fairly insist that the other party conform to the first's convenience or lose in perpetuity an equitable and vast share in a natural resource common to both countries.

In such cases the practice often followed in the United States is for the one whose needs are pressing to finance the work and be recompensed when the other partner or partners begin to join in the use—often the first cost is borne in perpetuity by the builder and stored water sold to the other partner or partners at cost.

The difference in results to the Sudan of Egypt's building the Gebel Aulia Dam now and taking all the conserved water thereby, or of the two parties sharing equally conserved waters and costs is very serious. As already stated, the Sudan is paying about £2,700,000 for a diversion weir and £300,000 for .47 milliards of storage, or £3,000,000 for both diversion and storage, by virtue of which 300,000 feddans can ordinarily be irrigated. If Egypt and the Sudan were to join equally in the cost for storage and conserved waters from both Gebel Aulia and Makwar— $4.47 \div 2 = 2.23$ milliards net storage each—the Sudan would in practice use all the .47 milliards from Makwar and be able to use 1.76 milliards from Gebel Aulia to replace water abstracted from the natural flow of the Blue Nile now used by Egypt. With 1.76 milliards storage at Gebel Aulia used to add to the natural flow below Khartum in lieu of appropriated water diverted at Makwar, 1,050,000 instead of 300,000 feddans could be watered with equal assurance of ample water supply in years of low flow. In this way the Sudan would be able to increase the area possible of irrigation by the Makwar storage by 1,050,000 less 300,000, or 750,000 feddans, or $2\frac{1}{2}$ times, for about £1,090,000. If it is profitable for the Sudan to spend £3,000,000 for diversion and storage for 300,000 feddans now, it certainly would be fortunate to provide diversion and storage for 750,000 feddans more at little more than one-third the cost, or an average cost of about £1.40 per feddan for the additional area as compared with £10 per feddan on the 300,000 feddans.

The fourth point is that the waters which are to be conserved are only the excess over and above existing rights. The variations in such excesses are of course much greater than the variations in the total discharges. Hence the Sudan, which will always have to utilise almost exclusively excess waters, cannot afford to provide as fully as Egypt against years of low supply. Until the Upper Blue Nile storage may be completed, water shortages will occur every few years, and in years like 1913—14 there may be severe crop failures with cultivated areas at all reasonable for average years.

The fifth point is the enormous amount of storage required for as complete utilisation as possible—around 95 milliards as at Khartum. This would be divided as follows:—Aswan, 2.4; Gebel Aulia, 4; Makwar, .47; Upper Blue Nile, 11 (13.7 at actual dam site); Albert lakes, 77 (95 at actual dam sites).

The sixth point is that a fundamental basis of dividing the as yet unappropriated waters at all stages of development be adopted at the beginning. It is a fairly complex business at best—more so than one realises. Careful measurements must be kept at the upper and lower ends of reservoirs, and proper loss allowances be computed to determine the “natural flow” and taking care of “existing rights.” Reservoir losses must be kept as part of the draft, etc. The existence of first water rights on a given basis, second water rights on another basis, third water rights on still another basis, etc., leads to confusion and is conducive to bitter disputes. The greatest simplicity possible is highly desirable.

* * * * *

After these remarks a general consideration and report will be undertaken.

As in the case of examining the reliability of observed and deduced hydrographic data, it is deemed impracticable to take up and comment upon all the criticisms and

suggestions presented to the Commission in regard to these several matters herein located. Every point urged has, however, been carefully considered by the Commission, and the following statement is believed to set forth the essential findings of facts and deductions resulting from each study.

A. QUANTITY OF WATER AVAILABLE.

GENERAL DESCRIPTION OF NILE WATERSHED.

Although irrigation from the Nile is among the oldest, if not the oldest, artificial systems of land watering in the world, the boundaries of the Nile watershed are not very well known, particularly those portions which furnish most of the water yield. This is true because the water-productive part of the Nile lies chiefly within Equatorial Africa, a considerable part of which is even yet unexplored by Europeans.

Practically the same is true of precipitation data, so that not only the watershed but the rainfall upon it are known only in a general way.

Detailed knowledge of both the watershed characteristics and the precipitation upon it is available for the down-stream or northern portions, but these parts of the basin furnish but a negligible part of the run-off.

Fortunately, the significant fact in irrigation matters is the stream flow, the conditions throughout the watershed which produce the run-off being of little interest when discharge data are comprehensive and satisfactory.

One of the most important characteristics of the Nile is the fact that practically all the water which it carries comes from tributaries which enter at or above Khartum, 1,900 miles above its mouth. From that point northwards to the Mediterranean Sea the water in the river is constantly diminishing, due to heavy evaporation and negligible run-off—quite the reverse of most streams, which increase in volume due to tributaries entering all along their lengths.

DISTRIBUTION OF IRRIGABLE AREAS.

From approximately Khartum northwards, the Nile valley is narrow until Cairo is reached, where the Nile Delta Fan begins. This valley is, in general, sharply delimited by rather abrupt hills lying a few hundred feet higher than the Nile valley. Thus the areas available for irrigation north of Khartum are definitely restricted, so that the total area within the confines of Egypt proper which are available for irrigation should the water of the Nile suffice therefor are clearly defined to a peculiar degree.

Above Khartum, however, the valleys of the Nile tributaries are broad and the areas which it is feasible to irrigate are large and less clearly defined. At the same time southern areas have more rainfall, and as one progresses south, the need for irrigation, together with the water requirements of the lands, continually diminish.

Irrigation is first practised where the need for it is compelling. Thus it is that there is very little irrigation in the Sudan even to-day, although another very important and really determining factor is that all but a very few of the inhabitants of the watershed from some distance south of Khartum are yet little or not at all civilised.

One finds it difficult to understand how it is possible that perhaps the oldest civilised area in the world is that about the lower reaches of the Nile, while two-thirds of the way up to the head waters of the stream, primitive people and original conditions are found. The causes responsible for the situation in the upper reaches of the river are, however, changing. Suppression of the slave trade, sanitation, including the treatment of the mosquito problem and tropical diseases generally, together with a stable and progressive Government—all quite recent—are beginning to show results, so that greater development of irrigated agriculture from Khartum south will doubtless take place within the next few years than has occurred from the beginning of time to the present date.

It is this fact which renders the allocation of the present unappropriated waters of the Nile between Egypt and the Sudan so very important.

CHARACTERISTICS OF NILE FLOODS.

The general facts about the Nile's flow have been known for many centuries—that there comes a summer flood with silty water which rises slowly and slowly recedes. Indeed, the maximum height this flood attained was a measure of the taxation of lands from the dawn of history until recent times and, in a certain sense, continues to this day. On a little closer examination the variation in the main tributaries are, however, quite as significant so far as the complete utilisation of the Nile is concerned.

In a general way the Main Nile may be considered as beginning at Khartum, where the Blue Nile joins the White Nile. These two main tributaries have strikingly different characteristics. The Blue Nile contributes nearly three times as much water as the White Nile; it has very wide discharge variations throughout the year; only about 8 per cent. of its total yearly flow at Khartum originates above possible reservoir sites; it causes almost all the volume of summer floods in Egypt; and at its high stages carries a large amount of silt. In other words the Blue Nile, which contributes most of the water, is, broadly speaking, "flashy," and has sharply limited conservancy possibilities.

The White Nile, on the other hand, is a stream of singularly even flow, due to its passing through water bodies of enormous volume, namely, Lake Victoria, Lake Albert, and the Sudd region. Here, too, is a serious extreme—just as the Blue Nile is peculiarly lacking in storage opportunities, the Upper White Nile is overburdened with very large water bodies, and a great part of the water which the stream would otherwise carry is wasted in evaporation from surfaces of the lakes and swamps through which it passes.

Below the junction of the White and Blue Nile one important stream enters namely, the Atbara. This river is even more flashy than the Blue Nile, being at times entirely dry, and is in severe summer flood at the same time the Blue Nile is, while it seems to have no conservation possibilities at all.

REGULATION POSSIBILITIES ALONG THE NILE.

While exploration of the Blue Nile drainage system for water storage sites has not been exhaustive, yet enough is known to indicate pretty definitely that conservation opportunities are confined to the Upper Blue Nile reservoir. The amount of storage which can be created here is very great, but the determining factor is that the run-off at the dam site is not to exceed 10 per cent. of that of the Blue Nile waters passing Khartum, which becomes, after transit losses, 8 per cent. at Khartum of the Blue Nile discharge.

Approximately half the White Nile at Khartum comes from the Sobat. This stream drains territory similar to that of the Blue Nile, so that it has wide variations of flow. Examinations made thus far indicate the impracticability of conserving its waters in any storage reservoir above its mouth.

POSSIBILITIES ALONG THE NILE FOR INCREASING THE TOTAL DISCHARGE.

There are two general ways of increasing the amount of water available for irrigation:—

- (1) To hold back discharge during periods when there is an excess of water for use during the critical periods.
- (2) To reduce water wastes.

Broadly speaking, there seem to be no opportunities—at least no important ones—for eliminating water wastes on the entire Blue Nile system, on the Atbara, or

on the Sobat branch of the White Nile. On the other hand, the opportunities for water-waste prevention on the Bahr el Gebel branch of the White Nile are exceedingly great.

About half of the water which comes into the stream from Lake Victoria and Lake Albert is lost in the Sudd region—a large flat, swampy area extending from Bor northward to Lake No. If this water waste could be prevented entirely it would be the equivalent of bringing in another tributary having an annual discharge equal to that of the Sobat, so that the opportunity which here exists of water-waste prevention is probably the greatest obtaining anywhere in the world.

DISCHARGE DATA AVAILABLE.

In order to examine the possibilities of increasing the water available for use during the irrigation seasons along the Nile, it is necessary to examine carefully the discharge data, by months and by years, of the several tributaries.

The engineer would naturally infer that thousands of years of water use for irrigation probably mean long and valuable records of stream flow. As a matter of fact, however, except for one record on the main Nile just below the Aswan Dam which goes back fifty years, reasonably reliable discharge records are only twelve to twenty years in length. That is to say, they are shorter than those easily available on the more important streams in the western and newest parts of the United States.

There are gauge records of the readings on the Rodah gauge at Cairo for several centuries. Unfortunately these data throw little light on the relative and absolute discharges. Not only are the amounts of water diverted from the river above Cairo at different periods unknown; but the channel from Cairo to the sea has often changed and modified the gauge heights at Rodah to such an extent as entirely to nullify their having any significance concerning relative discharges. Another factor diminishing the value of these records is the possibility that the recorded gauge readings may have been other than the actual ones, since taxation of the country used to depend upon the officially recorded Rodah gauge-heights.

All but the most recent discharge records are based upon gauge readings and discharge curves drawn chiefly from float discharge observations. Indeed, current meter measurements were not carried on to any considerable extent prior to 1914. Thus the degree of precision of most records previous to that date is not very great.

This condition of affairs is unfortunate, because for the wisest design of so important and costly works as must be constructed completely to utilise Nile waters for irrigation precise discharge data should be available.

One very important exception must be noted—the records of flow taken at the Aswan Dam. The degree of precision attained there is doubtless greater for large discharges than has ever been attained anywhere in the world. It is to be hoped that the paper prepared by Sir Murdoch MacDonald and Mr. H. E. Hurst on Aswan Dam discharges for the British Institution of Civil Engineers will soon appear and render most important technical information available to the engineering profession.

The tables at the end of this section of the report show the relevant discharge data extant and their relative degree of precision.

LOW YEAR CYCLES.

Experience all over the world shows the occurrence of low year cycles of run-off which are considerably under the average for an extended period, and single years during which the flow may be excessively small. In the absence of over-year storage the quantity of water discharged by the stream in a single year is very important. If, however, over-year storage is provided, the actual discharge of any one year is not so important, and it is the sequence of low years which presents the governing conditions.

Unfortunately the really available discharge records on the Nile do not cover a sufficient period of time to justify very definite judgments about cycles of low run-off.

Especially is this true since the probable error of discharge observations during the earlier part of the only long term record—fifty years at Aswan—is relatively large. Further, whether the later years of this series are much below a long period record or the earlier years thereof somewhat above cannot be determined.

Under the circumstances, the only thing possible is to examine the water supply available in the light of the records which cover both the main river and all its main tributaries. This is for a period of fourteen years from 1905 to 1918.

This fourteen-year period is very probably one of low flow, and so decisions based thereon are to be considered conservative. On the other hand, fourteen consecutive years, even though they were exceptionally dry, make a cycle so long that provision for it is necessary, especially in a densely populated country like Egypt.

FACTORS DETERMINING THE EXTENT OF REGULATION DESIRABLE.

As is usual in such cases, the seasonal distribution of the discharge is different from those of irrigation demands, so that a fairly complete utilisation of the stream flow requires holding back the water at times to increase the flow at other times. The extent and direction of regulation desirable thus depend not only upon the discharge but also upon the water requirements.

B. QUANTITY AND SEASONAL DISTRIBUTION OF WATER REQUIRED.

WATER REQUIREMENTS BY MONTHS.

The water requirements of lands irrigable from the Nile depend upon the relative amount of land to be watered by basin and by perennial irrigation. By basin irrigation is meant the application of water upon large areas during flood stages when large amounts of water can be turned upon the land by gravity. By perennial irrigation is meant the use of water throughout practically the entire year, and particularly at times when the Nile is not in flood and the ancient basin system of irrigation impossible.

Perennial irrigation enables a greater variety of crops to be grown and particularly the long staple cotton which is Egypt's greatest money crop. Lands which can be perennially irrigated are consequently much more valuable than those subject only to basin irrigation. Hence very large expenditures are justifiable to render a large part of, and if possible all, the lands irrigable from the Nile subject to perennial instead of basin irrigation.

It is of prime importance, therefore, to determine the upper limit of the perennially irrigated land capable of being served from the Nile. Even though controlled to the maximum extent, it might be that large volumes of water passing during floods can be utilised only for basin irrigation, which, while less profitable than perennial irrigation, is nevertheless better than none.

In most irrigation projects of any size there are fairly wide differences of opinion as to water requirements for optimum crop returns. The ones under examination are no exception, and many considerations and opinions were submitted to the Commission by Government officials, Egyptian engineers and agriculturists. The figures adopted by the Commission for Egypt are practically the same as those presented by Mr. Victor Mosséri and based upon the very large amount of data which Charles Audebeau Bey and he have carefully collected and skilfully analysed for many years past. These are not very different from those of the Government in the low-water stages, but are considerably larger during the months of flood. Incidentally such increases in seasons of large flow are of relatively slight importance as regards storage required since during these months large amounts of water normally waste into the sea. The figures adopted by the Commission for the Sudan are identical with those given in "Nile Control," p. 35.

Such ultimate water requirements by months for Egypt, for the Sudan, and for the two combined, are given in the table annexed to this portion of the report.

DESIRABLE REGULATION AND RIVER FLOW.

If it were possible to do so, the flow of the Nile throughout each year by itself should be regulated from the way in which it actually occurs to correspond to the total requirements. In addition, it would be desirable to hold back the water during years of large discharge to supplement the flow in dry years. Indeed, the ideal thing would be to regulate the discharges of the streams which actually occur throughout varying seasons and varying years so that there might be identically the same total discharge throughout every year and thus utilise all of the flow.

It is often possible to do this very thing with streams used for irrigation, city water supplies, etc., but the opportunities for such conservancy on the Nile are sharply limited. Only about 6 per cent. of the total discharge passing Khartum originates above the sole storage opportunity on the Blue Nile system, and about 12 per cent. passes Mongalla, above which are the large storage opportunities in the Lakes Albert and Victoria. The ultimate flow passing Khartum from this source when the Sudd waste is prevented will be about 24 per cent.

On the White Nile, between Khartum and the mouth of the Sobat, the storage opportunities are limited to the trough of the Nile, which, while affording large capacity, is very wasteful.

Due to this condition of affairs it seems impossible, considering the available discharge data for the period 1905—18, ever to utilise more than about four-fifths of the Nile's mean annual discharge for perennial irrigation. To do even this much will require very large over-year storage and very expensive water-waste prevention works.

AREA SUSCEPTIBLE OF IRRIGATION.

The data as to the areas in the Nile valley which could be irrigated from the river and its tributaries are not very complete. The area in Egypt is definitely known. In the Sudan there are 3,000,000 feddans in the Gezira controlled by the Makwar Dam now building, at least 1,500,000 more to the south requiring domestic and stock water to render possible gathering of rain-grown crops, and large areas along the White Nile further south where dry farming is possible but where ultimately more or less irrigation would be profitable. While the water requirements for the Sudan are incomplete, nevertheless the information now at hand is at least as satisfactory and sufficient as the discharge data for a period of any length at the various controlling gauging stations on the watershed.

The water requirements of these areas are equal to all the water which, as far as can now be foreseen, can be made available for perennial irrigation, and for less than complete conservation—which is merely a possibility—only a part of the lands can be watered. Hence the determining of existing water rights and the allocation of unappropriated water between Egypt and the Sudan is a matter of prime importance. So far as this report is concerned, each governmental unit is considered as apportioning its share of the water to the various lands within its own boundaries as may best suit its purposes.

C. ALLOCATION OF WATER.

The conditions obtaining during the several stages of conservancy in the Nile watershed differ so greatly that the allocation of water in an equitable manner requires first ascertaining a rule or principle of general application.

To permit of using a few expressions in an exact sense these will be defined.

“ Natural flow ” means the quantity of water which would flow in any channel were there no artificial interference to such flow at any point up stream.

“Water rights” means the vested rights, howsoever acquired, to divert and use water from a channel or water body.

“Unappropriated water” means the water which remains in a channel or water body after all existing water rights have been satisfied.

GENERAL PRINCIPLES.

There are several kinds of beneficial use which may be made of a stream's water. The most important are navigation, power development, irrigation, human and animal consumption. Broadly speaking, irrigation differs from the other uses in that relatively large quantities of water must be abstracted from, and only a portion can be returned to, the watercourse.

Regarding the beneficial uses of water, the legislation of the Occident, viewed as a whole, appears to start from the primary principle that every riparian proprietor is entitled to make a beneficial use of the natural flow of a stream running through or along his land, in its accustomed channel, undiminished in quantity and unimpaired in quality except as may be occasioned by the reasonable use of the stream on the part of other like proprietors.

This doctrine, however, has had to be abrogated or curtailed by constitutional or statutory amendments or by the effect of judicial decisions whenever found to be unsuited to the natural conditions of a given governmental unit, or inconsistent with the proper development of those industries or those beneficial uses of water which are deemed of paramount importance.

Whenever the rule remains in its pristine form, careful analysis will show that either the governmental unit which has adhered to the old system is supplied with a sufficient or evenly distributed rainfall or that its economic welfare is but slightly dependent upon utilising the water of its streams.

The Orient, on the other hand, has taken the principle that water is public property. It has adhered to but one rule in this regard, which as enunciated by Muhammad is “People are free partners in three things, water, vegetation which springs spontaneously from the soil, and fire.”*

In some portions of the Occident there is not an evenly distributed or sufficient rainfall, and as the development of these portions proceeded, the emancipation from the thralldom of the “riparian ownership” principle took place or is taking place. A usual change is to the doctrine of “prior appropriation.” This rule of “first in time, first in right,” implies that one who appropriates water is entitled to the full amount appropriated to the exclusion of all subsequent takers, the capacity of the first appropriator's channel fixing a limit beyond which he must not go in taking water but up to which he is *primâ facie* entitled to take.

This basis of adjustment works out in practice as long as there is in the stream a surplus of unappropriated water. A contingency often arises, however, where the potential water supply is materially reduced but along the banks there still remain large tracts of arable lands unwatered but irrigable belonging to different proprietors, including the original appropriator, all of whom simultaneously lay claim to the unappropriated water supply.

Neither the legislation, the jurisprudence, nor the diplomacy of the Occident has as yet laid down a principle of universal application affording a solution to the problem thus presented.

The original doctrine of “riparian ownership” obviously cannot be resorted to as an initial basis of reasoning.

* Hadith, compiled by Imam Alaa Eddin el Hanafi, Part VI., p. 189, line 1.

The rule of "first in time, first in right," fairly recompenses foresight and rewards enterprise. It finds its proper application as long as the potential water supply answers all existing needs. It recognises vested rights but limits these vested rights, and does not give a "first appropriator" a right of pre-emption upon the "unappropriated" water supply.

The civilisation of the Occident has sprung from lands where rain nurtures vegetation and there is ample water for potable and domestic use. The cradle of the Orient is largely a vast desert, redeemed from unproductivity by streams and springs, and therefore, in the very nature of things, the Near East looks upon water as a precious commodity and carefully provides for its distribution.

Thus one naturally turns to the basic legislation of the Orient for a suggestion. The East is a land of parables and the great truths of the Quran are often handed down in the form of parables. When, therefore, the apostles said to Saligh: "*You are naught but a mortal like ourselves; so bring a sign if you are one of the truthful*," he said: "This is a she-camel; she shall have her portion of the water and you have your portion of water on an appointed time." *

The word "*shirb*," which is used in the text, according to Maulid Muhammad Ali, the eminent commentator, "signifies either an act of drinking, or a share or portion that falls to one's lot of water, or a watering-place, or a time of drinking, and in law signifies the use of water for the watering of sown fields and of beasts." †

And then, again, it is decreed, "And inform them that the water is shared between them; every share of the water shall be attended." ‡

The tendency of modern Occidental water-right legislation is towards the final result of Oriental experience and a conserving of the natural resources on which depend the permanent prosperity and the equal opportunity of the people in a given governmental unit. The result has been that many recent enactments in semi-humid and arid areas specifically declare that water forms part of the public domain and is in no sense private property.

It is, therefore, the duty of Governments to consider that the use, conservation and development of water must be viewed as a public trust and administered in the interests of the beneficiaries of the trust, and accordingly with due regard to the eventual rights of generations yet unborn.

The principle being accepted, it follows that, in the contingency before cited, the arable lands unwatered but irrigable belonging to different proprietors, including the "original appropriator," enjoy an equitable right to an adequate share of the unappropriated water of a stream.

The proper conservation and development of the water yield from any drainage area will, in general, require the construction of storage or other works which should be located with due regard to the interests of the beneficiaries of the trust aforesaid.

Circumstances may obtain whereby the physical configuration of a governmental unit which comprises within its limits arable land unwatered but irrigable traversed by a stream makes it impossible for the said governmental unit to construct within its own borders such works as may be necessary for the proper conservation and development of the stream flow in question, although it would be physically possible for it to construct such works upon the territory of a neighbouring power.

The construction of such works upon the territory of a neighbouring power would be a violation of the sovereignty of the neighbour, and they therefore cannot validly be erected except as the result of an agreement.

* Quran, Sura, The Poets, verses 154—155.

† The Holy Quran, containing the Arabic text with English translation and commentary, by Maulid Muhammad Ali, *Islamic Review Office*, Woking, Surrey, England, 1917, exiii., 1275 pp., p. 736.

‡ Quran, Sura, The Moon, verse 28.

Should no such agreement exist, and it be desired that certain fundamental principles be enunciated as a basis of agreement, an equitable adjustment can be effected by considering the real nature of the rights of all parties.

Assuming that the consent of the neighbouring power has been obtained and that no third power asserts a conflicting interest, it becomes the duty of both high contracting parties to view the stream as an entity, to apply the principle hereinbefore enunciated to the stream as an entity, and to consider that the use, conservation and development of water must be viewed as a public trust and administered in the interests of the beneficiaries of the trust and with due regard to the rights of generations yet unborn.

The two governmental units, viewed thus as joint trustees charged with a common trust, can reconcile the interests of all concerned by acting as a "*bon père de famille*," that is to say, by solving the problem just as would a parent towards the children whose present and eventual interests were committed to his charge.

Such a one would begin by acquainting himself with the genesis, evolution and crystallisation of the law in respect to water rights. When he had thus prepared himself the conviction would be borne in upon him that in the Quranic maxims before cited, as well as the experience of the arid and semi-arid Occident, is found the key to the entire subject. He would therefore refuse to look upon a stream as private property but would view it solely as a constituent element of the public domain. He would also keep prominently before his mind the cardinal principle that the right of drawing water from a stream is not, in the last analysis, an attribute vested in the owner of riparian property, but a servitude due to the property itself as distinct from the present owner thereof or those who may inhabit the land at the moment.

In connection with the last clause it may be well to notice the suggestion sometimes made that the allocation of water should be based upon, or at least take into account, the population of the moment. Such an idea is untenable because, first, the vesting of rights to use irrigation water in *individuals* instead of making them appurtenant to *lands* would quickly bring about chaotic conditions; second, with regard to vested rights in general, the number of people in men's families is not considered in their adjustments; and, third, relative populations change enormously in short periods, due to civil and foreign wars and many other causes, and water diversions cannot practically be changed in synchronism—the very essence of water rights is that lands acquiring them should be assured of continual irrigation in future.

He would then require that he be advised:—

- (1) Of the full amount of water used throughout the various seasons of the year by each high contracting party during the past few years; and
- (2) Of the superficial areas of arable lands unwatered but irrigable of each high contracting party within the watershed of the stream and of their irrigation water requirements.

After having verified the respective figures so submitted, he would decree that:—

- (1) Each high contracting party should be considered as having a vested right in perpetuity to the supply of water when and as beneficially used by it during the past few years.
- (2) The unappropriated water possible of use with conservation should be divided among the two high contracting parties so as to in each case permit irrigation of like percentages of the superficial area of arable land unwatered but irrigable and lying within the watershed of the stream.
- (3) The cost of all works which may be constructed pursuant to the agreement in question, as well as all maintenance and operation charges in connection therewith, should be shared upon the basis of the quantity of conserved water each shall be entitled to receive, measured at the point of conservation, it being understood, however, that if either high contracting party should not desire or be able to advance its share of the first cost of any conservation work, its failure so to do in no sense estops it from eventually participating in the full use of the works aforesaid upon due payment of its proper share of the cost.

EXISTING WATER RIGHTS.

The officials of Egypt and the Sudan have submitted to the Commission a stipulation concerning the quantities of water which each has put to beneficial use up to the present time.

Some Egyptian engineers urged that these figures for Egypt should be somewhat increased. They, however, seem to be quite as large as the facts justify, and, indeed, are larger during months of low flow than the discharge of the river in all but the years of highest flood.

Plainly the taking of enormous quantities of water during the flood season, when there is an excess in the river over and above all possible requirements at that time, is no measure whatever of the quantity of water to which a right has been acquired in another season when the stream flow is very much less. Hence it is sufficient to set forth the total quantity of water used in an entire year, but the vested rights must be determined for each month by itself.

The data stipulated give the water diverted below the Aswan reservoir, which latter modifies the monthly distribution so far as amounts of the "natural flow" taken, and the latter are what is wanted. The figures for the used quantities entering the reservoir are essentially the same as for the quantities leaving it, except for the months of filling and of emptying. Since the amounts stated are maximum quantities for each month, the "natural flow" used will be taken as 2 milliards more for November and '5 milliard less for March, April, May and June.

The following table gives the figures adopted in millions of cubic metres :—

	Egypt below Aswan.	Egypt Natural Flow.	Sudan Natural Flow.
January . . .	1,500	1,500	139.5
February . . .	1,700	1,700	126
March . . .	2,400	1,900	31
April . . .	2,400	1,900	30
May . . .	2,500	2,000	31
June . . .	3,300	2,800	30
July . . .	3,700	3,700	255
August . . .	6,000	6,000	475.5
September . . .	8,700	8,700	323
October . . .	4,500	4,500	139.5
November . . .	1,500	3,500	135
December . . .	1,800	1,800	139.5
	40,000	40,000	1,855

It is recommended that Egypt and the Sudan be considered as each having a vested right to all the natural flow up to the amounts set forth in the second and third columns of the foregoing table.

Whenever there may be less water in the river than the combined vested rights, the supply should of course be divided in proportion to the respective rights of the two parties for that particular month in the year.

RESIDUE AVAILABLE FOR INCREASED IRRIGATED AREAS.

There is, of course, available for further use at any given time only the quantity of water in the stream in excess of the combined vested interests of Egypt and the Sudan for that particular time.

In every year, however, there is, at least during the peak of the flood, some water in the river over and above the combined vested interests at that particular time, and in years of high flood the excess is large. The mass curve shows the situation in this regard for the years 1905—14.

ALLOCATION OF UNAPPROPRIATED WATERS.

The physical conditions are such that practically no additional areas can be irrigated from the unappropriated water as it naturally flows. Increased use means that conservation works must first be carried out.

Such conservation will, curiously enough, be in three, and only three, principal stages.

The first stage is that resulting from completing the Makwar Dam on the Blue Nile and the Gebel Aulia Dam on the White Nile, both now under construction, as set forth in "Nile Control."

The second stage is that following the creation of large storage on the Upper Blue Nile.

The third stage will be attained when the Sudd Channel is completed to avoid the Sudd region entirely and large storage created in Lake Albert, Lake Victoria, or both. Storage at these lakes before making the Sudd Channel would hardly be justified, because the heavy losses in the Sudd would largely nullify any benefits, while once the very costly channel is made the lake storage would at once follow, as its cost would be only about 10 per cent. of that of the channel and would quadruple the increased flow due to the channel.

This programme seems to include all conservancy possibilities except one mentioned below and the suggested utilisation of Sudd storage by piecemeal development. The fundamental weakness of the latter and of any Sudd storage at all is the shallowness of water, and hence excessive losses both due to evaporation and plant transpiration. The only really effective treatment of the Sudd region is to avoid it altogether. Consequently the programme set forth in "Nile Control" seems the only possible one except as to one additional matter.

That is the suggestion to get more water by preventing the waste in the Sudd region of the doubtless large run-off into the Sudd from the watershed south-west of the Bahr el Ghazal. This stream generally traverses the western limits of the swamp area and must receive large quantities of water draining from the fairly high and generally steep catchment areas south-west of the Sudd. The rainfall must be fairly heavy on the higher portions and the total quantity of run-off quite large.

At present this water spreads over the western side of the shallow Sudds and is almost entirely wasted, so that the Bahr el Ghazal carries only about 20 cubic metres per second at its mouth near Lake No.

It is reported that a slight but well-defined ridge exists between the basins of the Bahr el Ghazal and the Bahr el Gebel, running northerly and southerly, and that if the water surface of the Bahr el Ghazal at or near Lake No were to be lowered a few metres, much larger quantities of water would drain to that point than do now. Added quantities would be secured by assisting the drainage into and through the Bahr el Ghazal by piecemeal dredging operations, and the upper limits of additional water thus to be secured might be quite high.

To obtain such lowering of the Bahr el Ghazal water surface near its mouth the suggestion is made to throw an earthen dam across it and instal pumping plants to lower the water level above the dam and discharge just below it.

Such an arrangement is, in effect, exactly that used in many places, notably in the low, swampy lands of the Mississippi delta, the difference being that there the aim

is to remove water from agricultural lands with the hope of minimum pumpage, while in this case the aim would be to secure water at the dam with the hope of a maximum pumpage. Indeed, it is possible that present swamp lands might also be reclaimed for agricultural use.

Undoubtedly additional water would thus be secured, and perhaps very large quantities. Estimates of the amounts are impossible to make from available data—indeed, no conceivable amount of observed data would enable more than rough calculations to be made. The only thing practicable in the circumstances is to instal pumps and see how much water is obtained. The results may be disappointing or, again, may be most gratifying. Pumping costs will be an important factor, but these will lessen per unit as the total quantities handled increase up to a rather large limit.

The success or failure of the experiment will hinge upon the cost of water secured. While it would be most interesting and perhaps very successful, until it is carried out it is best to neglect its possibilities in considering the complete utilisation of the Nile as a whole.

A careful examination of the results attainable from these three stages of conservancy, and of the areas and their water requirements in the Nile watershed, lead to the conclusion that the irrigation water requirements of the arable lands unwatered but irrigable from the Nile and within the respective boundaries of Egypt and of the Sudan, are practically equal—the Sudanese water requirements certainly equal, and perhaps exceed somewhat, those of Egypt. It is consequently recommended that the unappropriated waters be allocated to Egypt and the Sudan in equal portions.

To show the results which would follow such water allocation it is necessary to carefully analyse the records. To treat available and relevant data with precision would involve intricate calculations.

Results closely approximating the facts can be more easily and simply secured by reducing all discharges and storages to an equivalent located at Khartum. The accuracy of the conclusions will be nearly or quite as great as that of the discharge records taken as the fundamental bases.

Such reductions were made as follows :—

- (1) Adding 4 per cent. to Atbara discharges and considering it as emptying into the Blue Nile just above Khartum.
- (2) Considering losses and additions to the White Nile between Gebel Aulia and Khartum as zero.
- (3) Reducing the Sobat discharges by 10 per cent. and consider it as discharging directly into the Gebel Aulia reservoir.
- (4) Assuming 8 per cent. of the Blue Nile discharge at Khartum as originating above Lake Tsana and free from silt; the lake as located just above Khartum and indefinitely large; and that storage there would involve no additional evaporation or other losses.
- (5) Assuming the Bahr el Ghazal as having a uniform discharge of 20 cubic metres per second, and hence so small as to be negligible in comparison to the other figures.
- (6) For use in mass curves for the final stage it is assumed that the water passing Mongalla discharges directly into Gebel Aulia; that the quantity thus flowing is 75 per cent. of that observed at Mongalla; and that Lake Albert and Lake Victoria storage is indefinitely large and would involve no additional evaporation or other losses.
- (7) Assuming Egypt's ultimate requirements to be as per those adopted; to consider them as located just below Khartum; and to be increased by 25 per cent. to allow for transit losses Khartum to Aswan.
- (8) Assuming Sudan's ultimate requirements per 1,000,000 feddans, as given in p. 35 of "Nile Control," and as located at Khartum.
- (9) Assuming loss from Gebel Aulia reservoir as 4 milliards of cubic metres of water per annum and treated as part of the draw-off.

The results of such analyses show the following results of conservancy works as projected :—

First Stage.—(On completion of Makwar and Gebel Aulia Dams.) Storage capacity at Makwar 47 milliard, involving 2 milliard loss during each season ; gross contents of Gebel Aulia reservoir 12 milliards, involving ordinarily 4 milliards loss and adding 4 milliards to the summer flow of the White Nile, *i.e.*, 4.47 milliards will be added to the summer flow, all measured at Khartum, or 2.23 milliards for each country.

The cost at Makwar for storage may be taken as 10 per cent. of the reservoir's total cost, and for diversion, *i.e.*, raising the water to the canal headgates, as 90 per cent. ; cost of Gebel Aulia storage 100 per cent. of that reservoir's cost. The total storage cost will thus be 10 per cent. of, say, £3,000,000 = £300,000 at Makwar and 100 per cent. of £2,500,000 at Gebel Aulia ; or, say, £2,800,000 for adding 4.47 milliards to summer flow, or in the order of £625,000 per milliard added to the summer flow—about the same cost per milliard net storage at each place.

Such supplementing of the low flow will enable larger amounts of the natural flow to be utilised—the extent of this will be greater in the Sudan than in Egypt because much of Egypt's stored water will, as a practical matter, be used to increase the area planted with cotton rather than adding to the present irrigated area. In the Sudan it will enable the irrigation of 1,050,000 feddans in the Gezira.

Second Stage.—(The further creation of 13.7 milliards storage on the Upper Blue Nile—equivalent to 11 milliards at Khartum.)

Together with Gebel Aulia and Makwar such storage will enable the use of so much more of the natural flow of the Blue Nile as to add 20 milliards—as at Khartum—to the usable waters of the Nile under present conditions. Of this 10 milliards would go to Sudan and 10 to Egypt. That is to say, there would be water for a little more than 2,000,000 feddans in the Sudan Gezira. As for Egypt the extra areas depend very largely upon the disposition of the stored water whether to increase cotton areas or increase the lands watered according to the system now in use, or any variants between these.

The cost will probably be in the order of £3,000,000 for the construction works, but the engineering data are insufficient to say very definitely, while other expenses are but matters of conjecture. Perhaps the cost of adding the equivalent of about 12 milliards to the quantity of water utilisable will be around £250,000 per milliard.

Third Stage.—(Adding then the Sudd Channel and ample storage at Lakes Albert and Victoria.)

The completed conservancy works would, if they had existed in the period of years 1905—18, have permitted the utilisation of about 80 per cent. of the main flow of the Nile, and provided for all the irrigation needs of Egypt and 3,300,000 feddans or their equivalent in the Sudan Gezira. That is to say, it would practically provide for irrigating all the lands needing irrigation in the whole watershed. It would add about 40 milliards to the utilisable waters of the Nile over existing conditions—20 milliards for each country.

RELATIVE EFFECT OF STORAGE.

It will be noted that a little storage adds greatly to the amount of utilisable waters of the Blue Nile, more storage less, and that from the second to the third stage the extra amount of utilisable waters are but doubled by adding over four times the then existing storage. This is due to the Blue Nile being such a “flashy” stream, where a little storage has great value in adding to the low-water flow, while the White Nile is such a steady stream it requires great storage to attain much of a result, and then chiefly as over-year conservation.

RIGHTS TO SILT.

The Committee of Egyptian engineers strongly urge the importance of Egypt's vested rights in the silt, which is carried almost wholly by the Blue Nile water. This is not surprising considering that Nile silt has been the fertilising element of Egyptian lands from time immemorial.

Plainly the same principles which apply to appropriated and unappropriated waters should govern in the case of silt as well. That is to say, the vested rights of both Egypt and the Sudan are not for a given quantity considered yearly but must be taken month by month.

Now Nile waters are silty only when in flood, and practically all the silt is carried in the Blue Nile and the Atbara. Only about 8 per cent. of the flow of these combined streams can ever be stored, and then only at Lake Tsana, which to-day discharges practically siltless water, and hence additional storage there will not reduce the silt content of the Blue Nile water.

The storage at Makwar will probably result in some silt deposition. The limits of such action can be seen by remembering from the silt data taken in the Blue Nile that the average amount of silt passing per annum is 60,000,000 tons. This is equivalent to about 35,000,000 cubic metres of deposited silt. The Makwar storage is 467,000,000 cubic metres. Thus if the water below the dam were to be entirely clear the storage would be obliterated in about 15 years. If no deposition takes place the storage would last always and no silt reduction ever occur.

The real result will no doubt be nearer the last than the first limit, and it is improbable that 10 per cent. of the silt passing in any year will be deposited in the reservoir. All of this would be in the two flood months when in all but the years of lowest flow water will be wasting to the sea in large quantities. Thus the reduction of silt in the water Egypt receives at any of the three stages will be quite small.

Furthermore, it must be remembered that the use of Gebel Aulia storage will result in withholding White Nile water entirely during the time when the Blue Nile is silty, so that the water at such times below Khartum will tend to be more heavily charged with silt than at present. It is probable that the net result of the combined storages at Makwar and Gebel Aulia on the silt content below Khartum will be almost nil and might even be an increase during the silt-carrying season.

ADJUDICATION BOARD.

Even then many questions of interpretation of agreements and principles will come up so that for this and other reasons the administrative organisation of the Nile River as a whole is important. After careful consideration it is suggested that the adjudication of all questions arising concerning water rights and divisions, maintenance and operation of jointly-owned structures, etc., be lodged with a Commission consisting of at least two, and doubtless most of the time three, members, namely, one from the Egyptian Ministry of Public Works or some other official to represent the Egyptian Government, one from the Sudan Ministry of Public Works or some other official to represent the Sudan Government and a third neutral member selected by the two Governments jointly, who will be neither Egyptian, Sudanese nor English.

D. OBJECTIONS URGED TO THE PROGRAMME BY EGYPTIAN ENGINEERS.

A Committee of Egyptian engineers, of which Abdullah Pasha Wahby, the well-known Egyptian irrigation engineer, is the chairman, filed with the Commission a printed document entitled, "Criticism of the Nile Projects submitted by the Committee of Egyptian Engineers to the Nile Projects Commission, 1920." In addition to the formal submission of this document, the Committee of Egyptian engineers appeared

before the Nile Projects Commission, both formally and informally, and numerous informal conferences were held with one or more of the members.

So far as the criticisms cover the engineering features of the matter, they will not be treated in detail—just as the volume “ Nile Control ” is not—but are considered as having been answered, or at least dealt with generally, in this statement.

However, other objections which were raised by this Committee of Egyptian engineers will be separately taken up and carefully considered.

As is well known, “ The Nile is Egypt,” and the first objection urged is the construction of control works upon the Nile River system outside the territorial boundaries of Egypt. This objection is valid—no one wishes to have a construction of vital interest to him on lands he neither owns nor controls ; but there seems to be no place within Egyptian territory where additional water can be conserved—at least in any effective quantity—and if this is true irrigation development in Egypt stops practically where it is or conservation works outside Egypt must be accepted.

A second objection is to the construction of works in the Sudan before entering into an agreement between Egypt and the Sudan setting forth explicitly the rights and obligations of all parties, and making such agreement public. It is, of course, natural for irrigators to fear imposition on the part of those diverting water above them, even under binding contracts and laws, and in a matter of such importance as irrigation to the Egyptian it is natural for the owner to be nervous about the actions in the premises of any agent, no matter how fully trusted. It would seem desirable to have a complete understanding between Egypt and the Sudan, and this would obviate the objection under consideration. At present the head of the irrigation work in both countries is apparently free to exercise his own discretion in all operation matters.

A third objection is that, even though a satisfactory agreement existed between Egypt and the Sudan and that a Board comprised as previously suggested were in charge of interpreting it as a court of final resort, there would still be lacking the physical force to enforce the Board's orders. It was urged that in the dry years, when observance of existing water rights would cause serious water shortages in the Sudan, and in years like 1913—14 complete crop failure, the Sudanese would leave no stone unturned to secure more water at Egypt's expense, especially as the Sudan crops must be planted in July, when little indication exists as to the following months' water supply. Those experienced with irrigators realise there is force in such an objection, but the degree of force in the general agreement, which is necessary between Egypt and the Sudan, is not an engineering matter and is outside the purview of the Nile Projects Commission.

A fourth objection is that the Gebel Aulia and Makwar Dams would afford physical means of arbitrarily controlling Egypt's water supply adversely for political or military purposes. It is true that by opening sluices during floods and closing them in low water Egypt's summer water supply could be almost quite cut off. Such a possibility, however, exists in most storage works for irrigation, and in any event this objection is quite beyond the elements the Nile Projects Commission can take into account.

A fifth objection is reduction of silt. This is not well founded, as hereinbefore explained.

A sixth objection is that the supply for Egypt would come to a greater extent from the White Nile than now and be less satisfactory from a hygienic point of view, especially as there would be drainage from the Gezira getting into the White Nile. The importance of sanitation is very great, so that the common idea that the Blue Nile waters are better for potable purposes than those from the White Nile requires examination.

Both the White and Blue Niles drain watersheds sparsely inhabited above about 200 kilometres from Khartum. The White Nile is rich in organic matter taken up in the swamps of the Sudd region, while the Blue Nile contains very little. There is also

more mineral matter—the water is harder—but both streams near Khartum are relatively soft. The reason for the ancient and still existing preference for Blue Nile water is the lower organic matter content, and is based upon the old ideas concerning the relationship between substances in solution and water-borne diseases.

The germ theory of diseases is a quite recent one. Before its elaboration experience with various diseases had indicated casual relationship between night air in swampy regions and malaria; between drinking water and cholera, etc., etc. It is now known that malaria is transferred from one human being to another through certain species of mosquitoes; that cholera is caused by the vital activities of the so-called *Comma Bacillus*, etc. There is a casual relationship between night air from swampy regions and malaria, but that relationship is not due to the *air*, but it is that in such air there probably are mosquitoes of the particular type which transmits malaria.

Similarly, it is now known that typhoid fever is caused by the *Bacillus Typhosus*, which gets into water only through human faecal matter, and is not caused by organic matter in solution.

Until as recently as 1895 sanitarians judged the potability of water almost exclusively by chemical analyses. Such chemical analyses determined the amount of nitrogen in several forms, viz., free ammonia, nitrites, nitrates, and carbonic acid.

From the relative proportions of these substances, the extent of organic contamination was inferred—the best thing that can be done in interpreting chemical analyses of water. The real test is the possibility of the presence of human faecal matter as this may, at any time, mean the presence of *Bacilli Typhosus* and *Bacilli Coli Communis*. Sanitarians endeavoured to place limits on the safe quantity of organic matter, and very properly considered that the safe allowable quantity from animal sources was very much less than that from vegetable sources.

The most recent scientific investigation indicates a real justification for such differentiation between organic matter from animal and vegetable sources in that the vital activities of bacteria produce complex poisonous substances known as ptomaines, and these latter from animal are worse than vegetable organic foods for bacteria.

It is thus known now that the quantities of organic matter which streams carry are not indicators of the potability of their waters, provided that the amount of organic matter drawn from animal sources and from vegetable sources is not high according to the modern standards in such matters.

There are many creatures in the White Nile waters, such as hippopotami, crocodiles, fishes, and so forth, and the region in general has many birds. Great numbers of all of these are dying all the time, but it is to be remembered that such dead bodies are the food on which the others live. If it were not for this wise provision of Nature—that bacilli consume the decaying organic matter of all kinds, the vultures devour offal in a very much more rapid manner, and the denizens of any watercourse live upon the living and dead bodies of their own and other species—the waters of all streams would soon become literally “meat extracts.”

The White Nile is no exception to the general rule, and the Commissioners were particularly struck with the fact that in all the weeks spent traversing it not one dead body was seen floating, with the exception of two small fish.

The White Nile as it passes Malakal is but fairly high in organic matter, which must be chiefly vegetable in origin. Indeed, its waters would doubtless be preferred by sanitary engineers as the source of water supply for a large city over the Blue Nile, because filtration is more difficult and expensive in the case of water heavily laden with silt.

If the White Nile contained animal organic substances to an excessive degree, and mineral substances to any considerable extent, judging from accepted standards for potable water, it would be a different matter. However, the many chemical analyses

of the waters of these streams, which were carefully examined, show very clearly that in neither of these particulars are such limits at all approached. Furthermore, this condition of affairs will not be appreciably affected by drainage from even 3,000,000 feddans in the Gezira.

Nevertheless, the sanitarian on the Committee of Egyptian engineers is perfectly right in pointing out the importance of sanitation in connection with Egyptian irrigation. The avoidable increase in disease and mortality both of human beings and live stock when the water supply is low, to which he called attention, is not a thing of which to be proud. In all low flat countries irrigation brings in its train bad potable water conditions unless care is taken along sanitary lines, especially general educational work and inspection. It is to be emphasised that when enormous sums are expended on irrigation, proportional amounts should be appropriated to insure the general health being kept up to standards quite possible of realisation.

Lastly, it was suggested that the Makwar Dam was not essential for the economical development of the Sudan, and that irrigation water for the Gezira could be pumped up as cheaply as it could be diverted from the river by the dam under construction.

Now the mean lift for 300,000 feddans, including entrance and pipe-friction losses, would be at least 17 metres. Assuming an over-all efficiency for pumping plant of 70 per cent., the raising of 6,000 cubic metres of water—the annual requirements for a feddan—17 metres high will require 544 horse-power hours. That is to say, a horse-power year would be required to water 16·1 feddans. A horse-power year would doubtless cost, by any possible type of installation at Makwar, at least £30, and probably more. Hence the annual cost of pumping water per feddan would be at least £1·86. Taking interest at 6 per cent., and maintenance and operation charges at 4 per cent., or a total of 10 per cent., the capitalised cost of this would be £18·60. Hence the sum one would be justified in spending on a diversion structure to obviate the need for pumping would be £18·60 per feddan watered, or for 300,000 feddans $£18·60 \times 300,000$, or £5,580,000, while for 1,000,000 feddans the figure would be £18,600,000.

E. SECURING ADDITIONAL DATA.

The design and construction of conservation works after those at Gebel Aulia and Makwar are completed require much further study and collection of data. Regarding the latter, stress must be laid upon the necessity for employing the best method of collection and analysis. Above all, it must be recognised that continuity of work and unity of direction is imperative.

Egypt is entirely dependent upon irrigation for its existence ; scientific investigation pertinent to this subject is therefore of the greatest national importance. Further, scientific research is one of the duties of a civilised nation in order to contribute a share to the extension of knowledge for the benefit of mankind. The Irrigation Service in the past of necessity has had to devote most of its attention to construction, and there was no special branch charged with the accumulation of data and making of hydraulic studies. Furthermore, construction will take up much of the Service's energies in future, so that unless a special staff is set aside for such collection of data and study, it is inevitable that when sudden increases in the constructional work or other crises arise, gaps in the observations will occur. Such gaps will lessen the value of the remainder to an extent out of all proportion to the gaps themselves.

The general principle on which to work is the formation of a balance-sheet for each section of the river, that is to say, that the information should be such as will enable one to follow the flow of water from Lakes Tsana and Albert to the principal canal heads in Egypt and the Sudan. The programme should be a generous one, and the expenses incurred would be amply repaid by the value of the information in future.

It is understood that an extension of the existing discharge measurement work, and an increase in the degree of precision therein, is being drawn up by the Ministry of Public Works, and these comments are made to point out its particular importance.

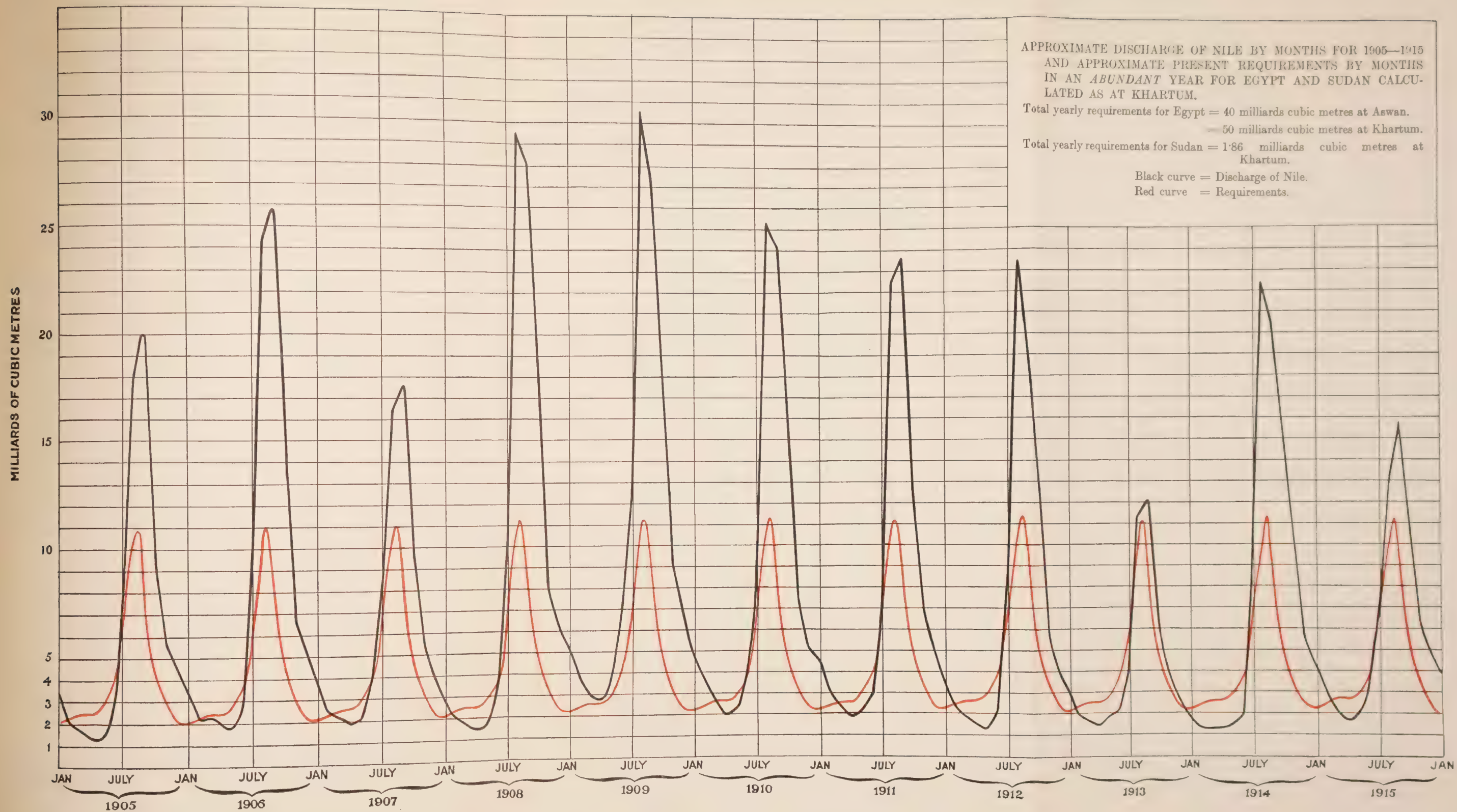
The rate of development in Egypt, and very likely in the Sudan as well, will no doubt be such as to require additional conservation works in practically the immediate future. Hence such collection of all possible essential data should be begun immediately.

F. FINDINGS.

Finally, the conclusions and recommendations are :—

- (1) Egyptian irrigation has practically reached its limit until conservation works are constructed outside its boundaries.
- (2) The programme outlined in " Nile Control " is the only practicable one.
- (3) The present uses of Nile water by Egypt and the Sudan, as shown in the table, should be adopted as vested rights to the natural flow.
- (4) The excess water over and above such vested rights should be divided equally between Egypt and the Sudan.
- (5) The costs of conservancy should be divided in like proportion, with the proviso that 90 per cent. of the total cost of the Makwar Dam be considered as for diversion only and paid wholly by the Sudan, and the further proviso that failure of one party to join in conservation work when such work may be required by the other in no wise estops the first party from eventually participating in the full use of such works upon due payment of a proper share in the costs.
- (6) The expenses of the Commission should likewise be borne in like proportions.
- (7) By complete conservancy, if that be found possible, the Nile waters will suffice for the irrigation of all irrigable areas in Egypt and probably most of those in the Sudan.
- (8) The objections urged against the proposed development, other than engineering ones, are outside the purview of the Commission.

(Signed) H. T. CORY.



APPENDIX

Charges brought by Sir William Willcocks, K.C.M.G.

CHARGE No. 1.

SIR WILLIAM WILLCOCKS charges Sir Murdoch MacDonald, the adviser to the Ministry of Public Works :—

- (1) With altering, or causing to be altered, the Blue Nile gauges at Sennar between early in December, 1913, and early in February, 1914.
- (2) With adding, or causing to be added, a greatly increased discharge to the volume of that river in this interval.
- (3) With the loss of a public document of prime importance.

I enclose three diagrams and one table in support of the charge.

In connection with the above I request the Commission to ask for and hold in its keeping :—

- (1) The Sennar gauge records from October 1st, 1913, to the end of March, 1914.
- (2) The Soba discharge file for 1914.
- (3) The originals of the Blue and White Nile Memorandums and their covering letters dated 19/2/14 and 18/2/14.
- (4) The original diagram showing :—
 - A. Blue Nile discharges in 1908 and 1914.
 - B. Discharges required in the Gezireh.
 - C. Total volume discharged at Sennar from 1907 to 1916.

.. (Signed) M. MacDonald, 20/5/17.

The above should be in Cairo.

- (5) The originals of the Blue and White Nile Memorandums and their covering letters in the file of the Sudan Government at Khartum.
- (6) The two documents dated 4/2/14 connected with the Sennar gauge in the file of the Director-General for Works, Khartum, which were shown me in March of this year.

Cairo, 28/4/20.

(Signed) W. WILLCOCKS.

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TABLE OF THE SENNAR ALTERATION, 1913-14.

Date.		Recorded gauges.		Difference, 3 and 4.		True Sennar gauge readings from diagram.	Discharges.		Excess discharge reported by Willcocks' discharge table.
For Rosiers.	For Sennar (5 days later).	Rosiers.	Sennar (5 days later).	Recorded.	True (see diagram).		True from the discharge diagram.	Recorded.	
1	2	3	4	5	6	7	8	9	10
1913.									
November 1-5	November 6-10	12-57	11-40	1-17	1-17	11-40	352		
" 6-10	" 11-15	12-37	11-29	1-08	1-08	11-29			
" 11-15	" 16-20	12-19	11-08	1-11	1-11	11-08	289		
" 16-20	" 21-25	12-02	10-92	1-10	1-10	10-92	241		
" 21-25	" 26-end.	11-88	10-83	1-05	1-05	10-83	214		
November 26-end.	December 1-5	11-75	10-74	1-01	1-01	10-74	192		
December 1-5	" 6-10	11-64	10-64	1-00	1-00	10-64	168		
" 6-10	" 11-15	11-45	10-56	-89	-94	10-51	139		
" 11-15	" 16-20	11-28	10-51	-77	-86	10-42	120	164	44
" 16-20	" 21-25	11-21	10-50	-71	-85	10-36	108	157	49
" 21-25	" 26-end.	11-15	10-47	-68	-84	10-31	99	150	51
December 26-end.	1914.								
December 26-end.	January 1-5	11-10	10-42	-68	-83	10-27	92	140	48
January 1-5	" 6-10	11-07	10-38	-69	-83	10-24	87	132	45
" 6-10	" 11-15	11-03	10-31	-72	-82	10-21	81	125	44
" 11-15	" 16-20	10-98	10-26	-72	-82	10-16	72	118	46
" 16-20	" 21-25	10-91	10-20	-71	-81	10-10	64	110	46
" 21-25	" 26-end.	10-88	10-14	-74	-81	10-07	60	105	45
January 26-end.	February 1-5	10-87	10-09	-78	-81	10-06	59	98	39
February 1-5	" 6-10	10-87	10-05	-82	-82	10-05	58	91	33
" 6-10	" 11-15	10-87	10-04	-83	-83	10-04	57	85	28
" 11-15	" 16-20	10-87	10-03	-84	-84	10-03	56	73	17
" 16-20	" 21-25	10-84	10-00	-84	-84	10-00	52	69	17
" 21-25	" 26-end.	10-80	9-99	-81	-81	9-99	51	67	16
February 26-end.	March 1-5	10-80	9-98	-82	-82	9-98	50	64	14
March 1-5	" 6-10	10-79	9-97	-82	-82	9-97	49	62	13
" 6-10	" 11-15	10-78	9-94	-84	-84	9-94	46	60	14
" 11-15	" 16-20	10-77	9-94	-83	-83	9-94	46	60	14
" 16-20	" 21-25	10-81	9-98	-83	-83	9-98	50	59	9
" 21-25	" 26-end.	10-86	10-02	-84	-84	10-02	54	58	4
February 26-end.	March 1-5	10-80	9-98	-82	-82	9-98	50	64	14
March 1-5	" 6-10	10-79	9-97	-82	-82	9-97	49	62	13
" 6-10	" 11-15	10-78	9-94	-84	-84	9-94	46	60	14
" 11-15	" 16-20	10-77	9-94	-83	-83	9-94	46	60	14
" 16-20	" 21-25	10-81	9-98	-83	-83	9-98	50	59	9
" 21-25	" 26-end.	10-86	10-02	-84	-84	10-02	54	58	4
March 26-end.	April 1-5	10-75	9-91	-84	-84	9-91	43	58	15
April 1-5	" 6-10	10-68	9-86	-82	-82	9-86	38	57	19
" 6-10	" 11-15	10-82	9-96	-86	-86	9-96	48	56	8
" 11-15	" 16-20	10-82	10-01	-81	-81	10-01	53		

(Signed) W. WILLCOCKS, 28/4/20.

CHARGE No. 2.

(1) I accuse Sir Murdoch MacDonald, adviser to the Ministry of Public Works, of publishing false and exaggerated figures for the discharge of the Nile. These are given on page 11 of the Report of the Ministry of Public Works for 1912, printed in 1914, and given to the public. It is stated there that the mean supply passing Aswan was as follows, *as calculated from sluice discharges* at the dam :—

April	.	.	.	.	602 cubic metres per second.
May	.	.	.	.	580 „ „

The real figures as calculated were given in “The Annual Report of the Inspector-General of Irrigation for 1912,” published in 1914, and not given to the public. They are :—

April	.	.	.	.	532
May	.	.	.	.	512

(2) I accuse Sir Murdoch MacDonald of losing a public document of prime importance in connection with these figures.

(Signed) W. WILLCOCKS.

Cairo, 29/4/20.

In connection with this charge I ask the Commission to obtain from the Public Works Ministry the 1913/14 *White Nile project* for Gebel Aulia, together with Mr. Tottenham's report and calculations.

(Signed) W. WILLCOCKS.

CHARGE No. 3.

The discharge of the Nile measured by sluices at Aswan and assigned to the 1 w months of 1916, the last low year recorded in “Nile Control,” as compared to discharges credited to the Nile at Halfa, are grossly exaggerated.

(Signed) W. WILLCOCKS.

Cairo, 4/5/20.

In Lord Kitchener's time, a very carefully taken and continuous series of discharges by sluice and current-meter observations, through 1912 and 1913, resulted in the sluice discharges being found 13 per cent. *less* than the current-meter observations in 1912, and 14 per cent. in 1913. (I take the sluice discharge figures from the tables of “Aswan Reservoir Emptying” for 1912 and 1913, with evaporation added, and the current-meter records from page 237 of “Nile Control.”) All this happened before 1914 had cast its dark shadow over the Nile projects, and before there was any temptation to exaggerate the discharges. The record low year, 1900, and its satellites 1902, 1903 and 1905, had been buried and put out of the way, and the years of plenty ushered in by 1909 held the field.

The only conclusions Mr. Craig, the head of the Physical Service, could come to in 1913 from the facts before him were those he communicated to Lord Kitchener, who recorded them on page 25 of his Report on Egypt and the Sudan for 1912 (printed in 1913) :—

“The calculation of river discharges has lately been the object of an interesting inquiry. From calculations based on the volume passing through the sluices of the Aswan dam, it became apparent that the discharges taken in the ordinary manner by current-meters record annually a considerable percentage more water than really does pass at any given moment. The Survey Department has investigated this discrepancy mathematically and come to the conclusion that important reductions have to be made on current-meter volumes, amounting to as much as 20 per cent. during the flood, and 10 to 15 per cent. when the river is low. The means to be adopted for correcting current-meter records are under discussion.”

Both the current-meter records and the sluice discharges have since been corrected to some purpose.

If we turn to page 237 of "Nile Control," published in April, 1920, we find the mean discharges at Halfa in the low months of 1916, the last low year recorded, as follows :—

April .	400	cubic metres per second (I shall in future say cumsecs).
May .	360	" "
June .	460	" "

The "Regulation of Aswan Reservoir" for 1916 was given me by the head of the Physical Service at the end of December, 1919, by order of H.E. the High Commissioner, and the resulting figures for Halfa, working from sluice discharges, are :—

April .	.	.	.	445	cumsecs.
May .	.	.	.	425	"
June .	.	.	.	530	"

Here we see that the sluice discharges which were found to be from 10 to 15 per cent. *less* than the current-meter discharges in both 1912 and 1913, are in 1920 found to be from 10 to 18 per cent. *more* in the similar low year 1916.

Cairo, 4/5/20.

(Signed) W. WILLCOCKS.

CHARGE No. 3.

As an appendix to Charge No. 3 I give a quotation from "Nile Projects" :—

The Committee * having avoided answering the first charge, answers the second charge by a false quotation. The Committee stated that Lord Kitchener misquoted the memorandum put before him, and then added that instead of saying, as he had, that "a reduction of from 10 to 15 per cent. *has* to be made," he should have said "*may have* to be made." As a matter of fact, Lord Kitchener was right and the Committee wrong. The original memorandum ran : "reductions must be made which may amount to anything between 10 and 15 per cent." Having changed "*reductions must be made*" into "*may have* to be made," the Committee proceeds forthwith to *increase* the discharge by 5 per cent. to justify Sir Murdoch's exaggerated figures. *This is typical of its work.*

APPENDIX A TO CHARGE No. 3.

THE WATER ENTERING THE ASWAN RESERVOIR, LEAVING THE RESERVOIR, AND THAT UTILISED IN THE CANALS IN 1914.

At the bottom of page 29 of my "Blue and White Nile Projects," I had said : "From January to the end of May the seepage into the low trough of the Nile between Aswan and Cairo, principally from the million acres of irrigated land, is high enough to exceed the losses of the river by evaporation and pumps."

This statement was contradicted by the Nile Projects Committee, sitting in London, in para. 40 of their Report : "*The question of seepage has been neglected by us, and we give figures to show that for such a condition of the river it is unimportant.*"

On page 10 of "Nile Projects" I accused these figures of being "arbitrarily manipulated." This statement is now verified by a series of figures given on page 216 of "Nile Control." If we take the river discharges corresponding to the dates between April 10th and May 20th at Aswan, when the river was horizontal and free of trough effects, we find that the Nile was discharging 516 at Aswan and 519 at Assiut according to the current-meter used ; and, consequently, up to Assiut, the seepage counterbalanced all losses. Of the river from Assiut to the Cairo Barrage Mr. Hurst, commenting on these figures on page 258 of "Nile Control," says : "Return seepage evidently counterbalances losses in this reach during April, May and June, so that the discharges at Assiut, Wasta and the Delta Barrage are within 4 per cent. of each other."

* The London Nile Projects Committee.

The return seepage from Aswan to Cairo in 1914, according to this showing, counterbalanced all losses by evaporation and pumps. And yet we have the following extraordinary figures given us on pages 234, 235 and 236 of "Nile Control":—

The Upper and Lower Egypt Canals discharged in May, 1914 (330 + 130), or 460 cumsecs, while the discharges at Aswan were in April 550 cumsecs and in May 560 cumsecs. During the period covering the 460, the discharge at Aswan was 541. In other words, the discharge recorded for Aswan was 81 cumsecs in excess of the canal discharges.

If we turn to para. 40 of the report of the Nile Projects Committee, which sat in London (given on page 10 of "Nile Projects"), we find that Aswan, deduced from Wadi Halfa, gave 575 cumsecs against the 541 cumsecs of page 236 of "Nile Control," or 34 cumsecs more. We thus arrive at the extraordinary result that, if the discharges recorded for Halfa are considered, the excess of 81 is turned into an excess of 114.

Leaving all these contradictory figures alone, which are now made to prove one thing and now another, I shall make a rigorous examination of the figures given on page 216 of "Nile Control." As against the Nile at Aswan discharging 515.5 cumsecs during the horizontal period of 1914 in April and May, the Ibrahimia and the Delta Canals, as measured by the same current-meter, were discharging 482.5.

The canals were, according to their own figures, discharging 33 cumsecs less than Aswan.

During the whole of this period (page 106 of the Irrigation Report for 1914—15), the canals had a mean discharge of 465 cumsecs. Therefore, according to their figures, Aswan was discharging (465 + 33) or 498. From a "revised" table of Aswan Reservoir emptying for 1914, just given me by the Physical Service, the Aswan Reservoir was adding 175 cumsecs. Evaporation between Aswan and Halfa was causing a loss of 17 cumsecs. The discharge at Halfa was therefore $(498 \times 17 - 175)$, or 340 cubic metres per second, according to their own figures. The discharge recorded for Halfa during this period, in a series of figures just given me by the Physical Service and from which they calculated the figures given on page 237 of "Nile Control," is 418 cumsecs, or 78 in excess of that brought up from the canal discharges, taking their own figures in every case.

The recorded Halfa discharges were calculated from a series of discharges said to have been taken in 1914 and corrected after the comparison with standard current-meter No. 1848. The originals were 30 per cent. in excess of the truth. The corrected are 23 per cent.

I note in passing that, early in 1918, Mr. Hurst assured me that no discharges had been taken at Halfa in 1914. He was then ignorant of them; while Mr. Adamson, Inspector-General of Irrigation, was equally ignorant of the canal discharges. He told me on three different occasions that no all-round discharges of the canals at the Assiut and Delta Barrages had been taken by current-meter in 1914. These discharges have been kept in reserve to prove one fact in 1918 and the opposite fact in 1920. Thoroughly unreliable as they are, they are given on page 217 of "Nile Control," while the sound discharges at Halfa, taken in 1912 by Mr. Herbert and two other English surveyors, are left out. These latter give low figures and are of no value to "Nile Control."

Cairo, 22/5/20.

(Signed) W. WILLCOCKS.

APPENDIX B TO CHARGE No. 3.

DISCHARGES OF THE NILE AT HALFA COMPARED WITH THOSE AT KHARTUM IN 1914 AND 1919.

In Appendix A I had concluded by saying that the discharges brought up from Cairo, on the showing of the official figures, should have been 340 against the recorded 418. The recorded discharges were 78 cumsecs in excess.

I shall now bring down the discharges from Khartum, using only official figures.

The accompanying table gives (1) the official discharges at Khartum from February 1st to April 20th in 1914, when the river was slowly falling or steady and there were no trough complications ; and (2) the official discharges at Wadi Halfa from February 16th to May 5th corresponding to (1). The mean of the 80 days at Khartum is 476 and at Halfa 468, giving a mean loss of 8 cumsecs. This is the total loss in the Government records in the extremely low year 1914, following the very low flood of 1913, with trough effects reduced to a real minimum, and evaporation and water consumption for irrigation on a length of 1,533 kilometres acting on a low discharge and having free play.

I compare with this the loss between Khartum and Halfa in 1919, according to the Government's own figures handed over to me by Lord Allenby's orders. Khartum is from February 1st to May 20th when the rise began, and Halfa is from February 16th to June 5th. There was a steady fall of 370 cumsecs from 990 to 620, as against the fall of 60 cumsecs in 1914 from 520 to 460. In 1919 the mean discharge at Khartum was 789 and at Halfa 676, showing a mean loss of 113 cumsecs. And this is in a year when everything was against such loss.

It was to cover this glaring misrepresentation of fact that the statement was made on page 68 of " Nile Control " that the losses between Khartum and Halfa were 20 per cent. of the discharge. This is the absolute opposite of the truth. The loss from evaporation increases or decreases with the area of water surface exposed to the sun and has nothing to do with the depth of water. In the confined trough of the Nile between Khartum and Halfa, a rise of a few centimetres greatly increases the discharge at the time of low water, and scarcely affects the water surface. The lower the discharge the greater is the proportion of the loss ; and the greater the fall of the river the greater the diminution of the loss. Every factor in 1914 was for heavy losses, and every factor in 1919 for low ones.

Cairo, 24/5/20.

(Signed) W. WILLCOCKS.

Losses in the River between Khartum and Wadi Halfa in 1914 and 1919.

1914.					1919.				
Date for Khartum.	Dis-charge for Khartum.	Dis-charge for Halfa (15 days later).	Difference.	Date for Halfa.	Date for Khartum.	Dis-charge for Khartum.*	Dis-charge for Halfa (15 days later).	Difference.	Date for Halfa.
Feb. 1—10	520	551	+31	Feb. 16—25	Feb. 1—10	991	941	— 50	Feb. 16—25
" 11—20	487	526	+39	" 26—Mar. 5	" 11—20	953	890	— 63	" 26—Mar. 5
" 21—end.	480	489	+ 9	Mar. 6—15	" 21—end.	897	815	— 82	Mar. 6—15
Mar. 1—10	470	466	— 4	Mar. 16—25	Mar. 1—10	888	743	—145	Mar. 16—25
" 11—20	468	453	—15	" 26—Apl. 5	" 11—20	832	658	—174	" 26—Apl. 5
" 21—end.	465†	422	—43	Apl. 6—15	" 21—end.	778	641	—137	Apl. 6—15
Apl. 1—10	462†	427	—35	Apl. 16—25	Apl. 1—10	742	625	—117	Apl. 16—25
" 11—20	460†	411	—49	" 26—May 5	" 11—20	680	570	—110	" 26—Mar. 5
					" 21—end.	670	550	—120	May 6—15
Rise begins and with it trough complications.									
† These discharges are from 15—30 cumsecs higher than I calculate them.					May 1—10	632	507	—125	May 16—25
					" 11—20	619	497	—122	" 26—June 5
					Rise begins and with it trough complications.				
Mean	476	468	—8		Mean	789	676	—113	

All the above figures are official.

* Mogren + SoBa for White and Blue Niles at their junction.

APPENDIX C TO CHARGE No. 3.

CURRENT-METER OBSERVATIONS.

On page 250 we see it stated in the table at the top of the page that "the probable percentage difference of a single rating from the mean of a medium-sized Gurley current-meter (the kind ordinarily used) vary from ± 4.6 per cent. to ± 1.9 per cent." The only two current-meters we used in March in the Sudan were corrected by from 14 to 17 per cent. in diminution of the maker's rating. This is many times the figures given. It is truly wonderful that no check measurements with surface floats have been made all these years.

On page 251 it is stated that, in the neighbourhood of velocities of $\frac{1}{2}$ metre, the Physical Department rating gives absolute velocities within narrow limits. Of what use is a statement like this when the discharges which are principally called in question all have mean velocities which run from .148 to .116 metres per second? It is quite common to see lengths of the section where the current-meter refuses to turn round and the length is credited with a velocity of .03 per second. The discharges we took at Senna had velocities ranging from .120 to .180 metres per second. At the length I checked with a float, the difference was excessive, while at Tamaniat, with a velocity of $\frac{1}{2}$ metre per second, the difference had been infinitesimal. All these very low velocities, unless they are checked by floats, are quite unreliable.

The remarks about gauge-discharge curves are special pleading. Once the gauges are brought back to their correct zeros, and current-meters used only at velocities where they are quite reliable and floats elsewhere, there will be none of the difficulties which stand to-day like lions in the path of the Physical Service.

Cairo, 24/5/20.

(Signed) W. WILLCOCKS.

CHARGE No. 4.

The new Sennar gauge on the Blue Nile has been lowered by 35 cm. compared to the old gauge which was read from 1906 to 1914.

By this action the Blue Nile has been credited with exaggerated discharges in normal years, and all low years are practically normal at Sennar. In a normal year a gauge of—

11.00 is discharging about 171 cumsecs and is credited with 292 in the official table.

10.50	"	"	71	"	"	140	"	"
10.10	"	"	27	"	"	60	"	"

Cairo, 4/5/20.

(Signed) W. WILLCOCKS.

In connection with this charge I ask the Commission to obtain and keep in its hands the original seven-daily gauge reports for Makwar from 1912 to date.

THE LOWERING OF THE SENNAR GAUGE ON THE BLUE NILE.

I noticed that in the two low years 1919 and 1920, recorded gauges of:—

" 10.40 at Malakal and 11.00 at Sennar	} gave	10.00 at Khartum. 10.30 at Tamaniat,
--	--------	---

while in the low years previous to 1914 a gauge of:—

10.10 at Malakal and 10.60 at Sennar	} gave	10.00 at Khartum, 10.00 at Tamaniat.
---	--------	---

Knowing that in the low summers (which follow the poor floods) there is practically no correction for scour or silt at any of these four gauges, and knowing also that both the Tamaniat and Sennar gauges had been allowed to be destroyed by the Nile and either rebuilt or read by levelling, I concluded that the zeros of the new gauges had been deliberately lowered and more water put into the Nile on paper than there actually was. I was the more confident of this as the Khartum gauge standing in front of the Palace is, with Aswan, the soundest gauge on the Nile, and could always be referred to.

I may note, in passing, that Sennar, on the Blue Nile, records the discharges of that river, Malakal those of the White Nile, and Khartum and Tamaniat those of the Main Nile at the junction. Tamaniat is 44 kilometres from Khartum and the discharge site of the Main Nile. Through 1913 and 1914 (the gauge was erected in May, 1912), Tamaniat and Khartum read practically the same; Khartum is one day before Tamaniat.

I asked and obtained the permission of the Nile Projects Commission to take, in their presence, with the Government engineers, discharges of the river at Tamaniat and Sennar and check the gauges.

On March 10th we took a discharge at Tamaniat, with the Khartum gauge of the previous day reading 9.90, and Tamaniat on that very day recorded at 10.21. (I note here that for March 10th the recorded gauge at Khartum is 9.85, while the true reading was 9.88.) The discharge measured at Tamaniat worked out to 634, but the distances between the soundings measured by angles were extraordinarily irregular. Having always measured by distances plotted on the ground, I never thought of verifying the angles as I did the velocities and depths. If the distances had been as regular as they certainly appeared to be, the observed discharge would have been 600. From the discharge table, a reading of 9.90 at Tamaniat or Khartum gives 600 cubic metres per second, while a reading of 10.21 gives 755. When this was pointed out to the irrigation officials, they said that the recorded Tamaniat gauge reading was doubtful. They had never before said this of these records. The reading was more than doubtful. It was wrong.

On March 14th we took a discharge of the Blue Nile at Sennar and found as follows :—

The new gauge was reading 11.00.

The measured discharge was 182 cubic metres per second.

My Sennar table gives 265 cubic metres per second } Mean 278
and Hurst's table gives 292 " " }

for a gauge of 11.00, while

my table gives 171 cubic metres per second } Mean 180
and Hurst's table gives 190 " " }

for a gauge of 10.65.

We found that two steps of the *old gauge* of 1906—14 were still intact, and that, when levelled, they were found to be 35 cm. higher than the new steps. The irrigation engineers had recently changed all the bench marks so that we could not refer to them.

On the 16th I returned to Khartum, but was summoned back to Sennar by telegram on the 17th to see a groove cut on the side of the steps of the old gauge. On the 18th I returned to Sennar and examined the mark pointed out to me. The Italian foreman who had built the new gauge told me in front of the Government engineers that he had built the lower half of the gauge in April, 1916, and the upper part in May, 1918; that from April, 1916, till May, 1918, the lower part of the new gauge was read with the upper part of the old gauge; that the upper part of the old gauge was reading from half-metre to half-metre when he made the change and not from metre to metre; and that the bottom of one of the metre lengths of the old gauge could be seen some 15 cm. above the floor on one of the side walls. It could be seen, and I have depicted it upon the accompanying diagram.

I note here that in the book put before the London Nile Projects Committee and in the recently published gauges of the Public Works Ministry, it is recorded: "Since 1915 the lower part of the Sennar gauge has been broken. The gauge readings were taken by temporary means. Those for June 1st—30th, January 21st—June 5th, 1916; February 1st—May 31st, 1917; and May 6th—10th, 1918, are doubtful, and have been replaced by values obtained from Makwar gauge readings." This statement is not in accord with fact, because the lower part of the gauge was rebuilt in April, 1916.

When the lower half of the new gauge was built in 1916 and made 35 cm. lower than the old, the higher half of the old gauge could not be read with the lower half of the new gauge unless it was also lowered 35 cm. This was done by lowering by 35 cm. the upper halves of the metre steps of the old gauge, and bringing them within 15 cm. of the floors of the steps themselves, as shown in the diagram. The upper part of the old gauge, which had, with the rest of the gauge, run from metre to metre, now ran from half-metre to half-metre, and the bottom of the metre lengths were 15 cm. above the floors of the steps as the existing niche shows. The Italian foreman's statement was true to fact.

In 1918 the upper part of the old gauge was abandoned, and the new gauge raised to full height as we saw it on March 14th, 1920.

Nile gauges, which have to be read through the twelve months of the year and have, in consequence, to be placed in exposed situations free from shoals, are always in danger of being undermined and destroyed by the Nile unless they are well protected. Gauges which have discharge tables attached to them are important public works whose protection is imperative. For an engineer to see a gauge exposed to danger and to let it be swept away without making an effort to protect it is just as though he were deliberately to destroy it himself.

The Sennar gauge, to which the official discharge table of the Blue Nile is referred, and the Tamaniat gauge, to which the official discharge table of the Main Nile is referred, were two of the most important gauges in the Sudan. Both were allowed to be carried away without a cubic metre of stone or concrete being employed to save them. The Sennar gauge has been rebuilt with its zero 35 cm. lower than that of the old gauge; while the Tamaniat gauge has never been rebuilt, but levelled readings are recorded which are 30 cm. at least in excess of what they should be. This means that at a low gauge of 10-00 at Sennar the discharge from the table becomes 106 instead of 52 cubic metres per second; while at a low gauge of 10-00 at Tamaniat the discharge from the table becomes 800 instead of 650.

TABLE I.—*Hurst's Discharge Table for Sennar (1912).*

(Cubic Metres per Second.)

	0	1	2	3	4	5	6	7	8	9
12-00	750									
11-90	700	705	710	715	720	725	730	735	740	745
11-80	650	655	660	665	670	675	680	685	690	695
11-70	600	605	610	615	620	625	630	635	640	645
11-60	550	555	560	565	570	575	580	585	590	595
11-50	500	505	510	515	520	525	530	535	540	545
11-40	450	455	460	465	470	475	480	485	490	495
11-30	400	405	410	415	420	425	430	435	440	445
11-20	365	368	372	376	379	383	386	390	393	396
11-10	325	329	333	337	341	345	349	353	357	361
11-00	292	295	298	301	304	308	311	314	317	321
10-90	260	263	266	269	272	276	279	282	285	288
10-80	232	234	237	240	243	246	248	251	254	257
10-70	204	206	209	212	215	218	220	223	226	229
10-60	176	178	181	184	187	190	192	195	198	201
10-50	140	143	147	150	154	158	161	165	168	172
10-40	118	120	122	124	126	129	131	133	135	137
10-30	100	102	104	106	108	109	111	113	115	117
10-20	86	87	89	90	91	93	94	96	97	99
10-10	70	72	73	75	76	78	80	81	83	84
10-00	60	61	62	63	64	65	66	67	68	69

TABLE II.—*Willcocks' Sennar Discharge Table, built up with the Measured Discharges of 1919 referred to the Recorded Gauges of 1919 reduced by 35 cm.*

(Cubic Metres per Second.)

	0	1	2	3	4	5	6	7	8	9
11.50	415	418	421	424	427	430	343	436	439	442
11.40	385	388	391	394	397	400	403	406	409	412
11.30	355	358	361	364	367	370	373	376	379	382
11.20	325	328	331	334	337	340	343	346	349	352
11.10	295	298	301	304	307	310	313	316	319	322
11.00	265	268	271	274	277	280	283	286	289	292
10.90	235	238	241	244	247	250	253	256	259	262
10.80	207	209	211	214	217	220	223	226	229	232
10.70	183	185	187	190	192	195	197	199	202	204
10.60	159	161	163	166	168	171	173	175	178	181
10.50	137	139	141	143	145	148	150	152	154	156
10.40	116	118	120	122	124	126	128	130	132	134
10.30	97	99	101	102	104	106	108	110	112	114
10.20	79	81	83	85	87	88	90	92	93	95
10.10	64	65	66	68	70	71	72	73	75	77
10.00	52	53	54	56	57	58	58	59	61	62
9.90	42	43	44	45	46	47	48	49	50	51
9.80	35	35	36	37	37	38	38	39	40	41

(2) *I now tabulate the discharges of the Blue Nile taken near Sennar in the low years and compare them with the discharge tables. Mr. Hurst's discharge table was made in 1912 and I made mine from the 1919 measured discharges at Sennar referred to the old Sennar gauge, which stood till 1915, and which had its zero 35 cm. above that of the new gauge in existence to-day.*

Table III. compares the 1919 and 1920 measured discharges with the discharge tables, and proves that the measured discharges can nowhere be referred to either table.

Table IV. gives the measured discharges of the low years 1905, 1908, 1912, 1913 and 1914, taken near Sennar, and compares them with the discharge tables. It shows how well they agree. The discharges taken in 1905 are rugged compared with one another, gauge for gauge, but the observers were in those days not all of them skilful. In 1915 no discharges were taken near Sennar and none at all on the Blue Nile in 1916.

Table V. gives the recorded gauges for Sennar for 1919 and 1920, reduced by .35, and the measured discharges compared with the corresponding discharges from the two tables. The results are illuminating.

TABLE III.—1919 and 1920. *Sennar Measured Discharges compared with the corresponding Discharges from Hurst's Table and Willcocks' Table.*

1919.					1919.				
Date.	Gauge.	Measured Discharge	Hurst's Table.	Willcocks' Table.	Date.	Gauge.	Measured Discharge	Hurst's Table.	Willcocks' Table.
January 3	11.87	272	435	376	April 11	10.35	54	109	106
" 13	11.25	214	383	340	" 14	10.34	53	108	104
" 16	11.19	207	361	322	" 17	16.34	56	108	104
" 23	11.11	194	329	298	" 23	10.29	49	99	95
" 27	11.10	189	325	295	" 24	10.28	49	97	93
" 31	11.06	188	311	283	" 28	10.23	39	90	85
February 3	11.00	189	292	265	May 1	10.21	37	87	79
" 10	10.97	175	282	256	" 5	10.18	34	83	75
" 13	10.95	164	276	250	" 8	10.16	35	80	72
" 20	10.88	140	254	229	" 12	10.20	38	86	79
" 24	10.82	143	237	211	" 15	10.21	39	87	81
" 27	10.78	142	226	202	" 19	10.23	47	90	85
March 3	10.74	123	215	192	" 22	11.08	206	317	289
" 6	10.71	119	206	185	" 26	11.72	378	610	?
" 10	10.66	94	192	173	" 30	11.30	250	400	358
" 13	10.63	98	184	166	" 31	11.20	228	365	325
" 17	10.57	81	165	152	June 2	11.26	229	386	343
" 20	10.56	74	161	150	" 5	11.16	205	349	313
" 25	10.60	105	176	159	" 9	11.30	249	400	355
" 27	10.56	69	161	150	" 12	11.22	238	372	331
" 31	10.48	57	135	132	1920.				
April 3	10.44	60	126	124	March 14	11.00	182	292	265
" 10	10.36	62	111	108					

TABLE IV.—*The measured Discharges of the low years 1905, 1908, 1912, 1913 and 1914 compared with Hurst's and Willcocks' Tables of Discharges. The latter has been made from the 1919 Measured Discharges referred to the Sennar gauge for 1919 reduced by 85 cm.*

Date.	Recorded Gauge.	Discharges.			Date.	Recorded Gauge.	Discharges.				
		Measured.	Hurst's Table.	Will-cocks' Table.			Measured.	Hurst's Table.	Will-cocks' Table.		
1905.					1912.						
January	1	11.42	261	460	391	May	13	10.22	73	89	83
"	9	11.24	288	379	337	"	18	10.18	67	83	75
"	16	11.09	314	321	292	"	22	10.22	67	89	83
"	24	11.01	262	295	268	December	17	11.52	408	510	421
"	24	10.97	268	282	256	"	24	11.40	374	450	385
"	31	10.95	210	276	250	"	31	11.26	391	386	343
February	17	10.77	153	223	199						
"	27	10.63	158	184	166	1913.					
April	3	10.15	64	78	71	January	8	11.14	340	341	307
"	14	10.07	60	67	59	"	14	11.06	302	311	283
May	21	10.14	70	76	70	"	21	10.96	291	279	253
1908.					"	28	10.86	222	248	223	
March	18	10.30	87	100	97	February	4	10.75	199	218	195
"	31	10.24	98	91	87	"	11	10.68	185	198	178
May	1	10.08	63	68	61	"	18	10.64	183	187	168
"	3	10.13	63	75	68	"	25	10.60	171	176	159
1912.					March	4	10.55	153	158	148	
January	8	11.69	425	595	?	"	11	10.50	154	140	137
"	23	11.45	393	475	400	"	20	10.40	112	118	116
"	31	11.35	336	425	370	"	25	10.34	112	108	104
February	14	11.15	281	345	310	April	1	10.25	76	93	88
"	28	10.85	233	246	220	"	8	10.20	60	86	79
March	14	10.77	172	223	199	"	15	10.22	100	89	83
"	31	10.58	148	168	154	"	22	10.26	66	94	90
April	20	10.50	132	140	137	1914.					
"	26	10.44	125	126	104	March	26	9.99	64	?	51
May	7	10.27	76	96	92	"	28	10.03	60	63	56
"	9	10.26	75	94	90	April	10	9.88	45	?	40

TABLE V.—1919 and 1920. *Sennar Recorded Gauges reduced by 35 cm. and the Measured Discharges compared with the corresponding Discharges from Hurst's Table and Willcocks' Table.*

Date.	Recorded Gauge.	Discharges.			Date.	Recorded Gauge.	Discharges.		
		Measured	Hurst's Table.	Will-cocks' Table.			Measured	Hurst's Table.	Will-cocks' Table.
1919.					1919.				
January 3	11-02	272	298	271	April 11	10-00	54	60	52
" 13	10-90	214	260	235	" 14	9-99	53	?	51
" 16	10-84	207	243	217	" 17	9-99	56	?	51
" 23	10-76	194	220	197	" 23	9-94	49	?	46
" 27	10-75	189	218	195	" 24	9-93	49	?	45
" 31	10-71	188	206	185	" 28	9-88	39	?	40
February 3	10-65	189	190	171	May 1	9-86	37	?	38
" 10	10-62	175	181	163	" 5	9-83	34	?	37
" 13	10-60	164	176	159	" 8	9-81	35	?	35
" 20	10-53	140	150	143	" 12	9-85	38	?	38
" 24	10-49	143	137	134	" 15	9-86	39	?	38
" 27	10-43	142	124	122	" 19	9-88	47	?	40
March 3	10-39	123	117	114	" 22	10-73	206	212	190
" 6	10-36	119	111	108	" 26	11-37	378	435	376
" 10	10-31	94	102	99	" 30	10-95	250	276	250
" 13	10-28	98	97	93	" 31	10-85	228	246	220
" 17	10-22	81	98	83	June 2	10-91	229	263	238
" 20	10-21	74	87	81	" 5	10-81	205	234	209
" 25	10-25	105	93	88	" 9	10-95	249	276	250
" 27	10-21	57	87	81	" 12	10-87	238	251	226
" 31	10-13	60	75	68	1920.				
April 3	10-09	62	69	62	March 14	10-65	182	190	171
" 10	10-01	54	61	53					

(3) Now follows a series of discharges of the Blue Nile taken near Sennar in the high summers following the high floods, and compared with the tables. In such years there is often considerable silt. Scour is impossible at Sennar as there is a stone bar across the river, rendering it one of the best gauge sites on the Nile for low summers. In 1906 and 1907 there was no silt. In 1907 four very incorrect discharges were recorded at Sennar which run counter to every other discharge of the many taken that year. They follow each other and were doubtless due to some mistake on the part of the observer. I give them and the two before and after:—

Gauge, 11-06.	Discharge, 328.
" 11-00.	" 287.
" 10-93.	" 343.
" 10-94.	" 364.
" 10-82.	" 278.
" 10-70.	" 286.
" 10-63.	" 196.
" 10-61.	" 160.

They should have been omitted and not used to discredit the discharge tables. The summer of 1909 followed the torrential flood of 1908 and there were 50 cm. of silt on the gauge. The discharges of this year were so abnormal that Mr. Craig omitted the whole of them in his complete list of discharges of the Blue Nile published in 1910. He gave only one discharge which showed 25 cm. of silt, but

this one is now omitted from the Government reports. In the list of discharges reported to the London Committee, these abnormal discharges which were omitted by Mr. Craig were not published, but they are now given for the first time in the last publication of the Public Works Ministry. In the two high summers of 1910 and 1911 there were 12 and 16 cm. of silt respectively. All these were high years in which the Khartum gauge never fell as low as 10·00. They have nothing to do with the low summers in which there is no silting, and the stone bar prevents all scour at Sennar.

The Sennar gauge for low summers is an excellent measure of the low supply in the river. It is a far better gauge than Makwar, which is 7 kilometres upstream on the same reach of nearly horizontal water, and which rises far more rapidly than Sennar as the river rises.

TABLE VI.—*Sennar. High Summer Supply Years. Discharges near Sennar referred to the Sennar Gauge and compared with my Discharge Table.*

Date.	Gauge.	Discharges.			Date.	Gauge..	Discharges.	
		Observed.	From Table.				Observed.	From Table.
1906.				Very irregular, but practically the same as the table.	1909, following high flood of 1908.			
Jan. 21	11-32	368	361		Jan. 22	11-67	377	?
„ 30	11-15	246	310		Feb. 25	11-20	164	325
Feb. 8	11-01	223	268		Mar. 16	10-99	152	262
„ 28	11-17	266	316		Apr. 6	11-10	173	295
Mar. 21	10-77	219	199		„ 16	11-50	250	415
„ 25	10-99	289	262		„ 24	11-18	170	319
Apr. 8	10-99	254	262		„ 30	11-65	296	?
„ 28	10-56	104	150		May 8	11-52	260	?
May 22	10-40	127	116		„ 17	11-29	207	352
					Mar. 30	10-94	179	247
1907.				Irregular, but practically the same as the table.	About 50 cm. of silt.			
					1910.			
Jan. 3	11-68	536	?		Feb. 13	11-16	292	313
„ 10	11-54	417	427		Mar. 31	10-70	222	183
„ 17	11-42	426	391		Apr. 11	10-52	122	141
„ 26	11-30	362	355		„ 18	10-50	110	137
„ 31	11-26	332	343		„ 25	10-54	118	145
Feb. 10	11-14	350	307		May 5	10-46	92	128
„ 16	11-06	328	283		About 12 cm. of silt.			
„ 23	11-00	287	265		1911.			
Mar. 29	10-63	196	166	Mar. 1	10-92	192	241	
Apr. 5	10-62	160	161	„ 9	10-83	164	214	
„ 14	10-66	175	173	„ 19	10-84	182	217	
„ 19	10-95	273	250	„ 28	10-72	166	187	
„ 27	10-92	237	241	About 16 cm. of silt.				
„ 28	10-92	263	241					
May 6	10-75	254	195					

(4) *In the report placed before the London Committee, it is stated : “ Most of the discharges were taken at Soba ; these have been taken for discharges on a falling river “ to be the same as for Sennar on the same date. This may be justified by theory and “ also by practice in 1913.” Soba, I may state, is near the tail of the Blue Nile, 348 kilometres downstream of Sennar.*

This statement is contradicted *in toto* by the series of discharges taken in the low year 1919 at Sennar and Soba, which I give in full. It confirms the decision taken at Khartum in 1913 to make no further use of Soba as a discharge site for the Sennar gauges. There are two letters in the Soba file for 1914 which are echoes of this decision. The Public Works Ministry, in their amended and corrected report placed before the London Committee, should have cancelled the sentence quoted above, because the figures for 1919 were before them. I have left Soba altogether out of my calculations, and it is on this account that my discharge table is a truer measure of the water in the Blue Nile at Sennar than Mr. Hurst's table. I have only followed in the steps of the engineers themselves, when in 1913 they endeavoured, under Lord Kitchener, to get truly reliable figures for Sennar.

(5) *I now give comparative gauges for Roseires and Sennar (five days later)*, for the low years during the low months of March and April until the final rise begins. It will be seen that the mean difference up to 1914 is 15 cm. more than it is afterwards.

If, however, we take the two years of steady fall (without freshets), 1913 and 1919, we find a difference of 20 cm. This difference between the two is due to the fact that the Sennar gauge is apparently not read nowadays in the low stages but is calculated from Makwar, 7 kilometres higher up on the same almost horizontal reach of water, where the rises are more pronounced than at Sennar itself. The figures for 1916 and 1920, compared with those for 1914, three years of pronounced freshets, confirm what I have said. When we wanted, on March 14th this year, to read the step above 11.00 at the Sennar gauge, we had to dig a channel through the deposit left by the flood, showing that on the falling river the bottom of the step was not read. As Sennar has been lowered 35 cm., I conclude that Roseires has been lowered by 15 or 20 cm., probably 20. Lowered it has certainly been.

Cairo, 1/5/20.

(Signed) W. WILLCOCKS.

CHARGE No. 5.

The recorded gauge readings of the Blue and White Niles from 1915 onwards, and especially for 1919 and 1920, represent a joint discharge of the Main Nile greatly in excess of that warranted either by the gauge readings previous to and including 1914, or by those of Khartum or Wadi Halfa.

In sympathy with these excesses, the Tamaniat gauge readings, which used to be practically the same as Khartum or even a little less in the low months of low summer supplies, are now recorded as over 30 cm. in excess.

We know the discharges of the White and Blue Niles at Malakal and Sennar for the summer of 1919; but during the whole of 1919 only one discharge was taken of the Main Nile at Tamaniat near Khartum, showing an extraordinarily high discharge for the Khartum gauge; and then the Tamaniat gauge fell into the river, just as the Sennar gauge had fallen in 1915. Meanwhile no discharges whatever were taken at Halfa through 1915—16—17—18 and 1919. If we compare this evasion of check-work with the earnest experiments of 1912—13 we seem to be living in two different worlds.

While these extraordinary changes of gauges and discharges are taking place, it happens that the bench marks on the Blue Nile are all altered, and the moment is chosen to change the reduced levels of the zeros of the gauges by 4.82 metres and go back to the discarded zeros of many years ago. When we consider that all this time the complete gauges and discharges are not given to the public, and only selected figures given, it looks like a conspiracy to bewilder and confuse Egypt, and prevent her from sifting out the reason why the recorded gauges for the Blue and White Niles indicate excellent supplies, which the actual supply arriving at Halfa flatly contradicts.

Cairo, 6/4/20.

(Signed) W. WILLCOCKS.

CHARGE No. 5.

(1) At the beginning of the charge of "the lowering of the Sennar gauge," I had stated that, in the two low years 1919 and 1920, recorded gauges of 10·40 at Malakal and 11·00 at Sennar gave 10·00 at Khartum and 10·30 at Tamaniat; while in 1914 and previously a gauge of 10·10 at Malakal and 10·60 at Sennar gave 10·00 at Khartum and the same at Tamaniat. I had concluded that the Sennar gauge had been lowered and the Tamaniat gauge readings increased. (If the zero of a gauge is lowered the gauge reading, and with it the discharge, is increased.)

(2) When I returned from the Sudan on March 30th of this year and applied a correction of ·35 to the Sennar gauge readings I found that the differences between the correct and recorded figures at Sennar were not sufficiently great to account for the differences at Khartum. I turned to the figures for the White Nile and found that the recorded gauges for that river seemed also too high.

(3) I here give tables and diagrams showing the joint discharges of the White Nile at Malakal and the Blue Nile at Sennar, and comparing them with the discharges of the main Nile at Khartum and Wadi Halfa at low water in the years of low summer supply. The gauges and discharges for 1914 and previous to 1914 are compared with the gauges and discharges since 1914.

(4) The years 1900, 1902, 1903 and 1905 were low years, constituting a quite unique series of such years, but the Public Works Ministry cannot find the original records. I therefore take the recorded low years 1908, 1912, 1913 and 1914 as constituting one series, and 1915, 1916, 1919 and 1920 as constituting another.

(5) The gauges are referred to the Malakal, Tamaniat and Wadi Halfa discharge tables in the third edition of "Egyptian Irrigation," which were given me by the Inspector-General of Irrigation in 1912—13. The Sennar discharge table was prepared by the Physical Department in 1912 and is given in "Nile Projects." These are all tables prepared by Government officials.

(6) After good and high floods the beds of the Blue and Main Niles are often disorganised. Such floods are, moreover, followed by good supplies of water in the following summer, which flow down quickly and cannot be readily located. After poor floods and low floods the beds of the rivers are very fairly normal; and the gentle supplies of water obey fairly well the times indicated in Mr. Craig's time table for the Nile printed in the third edition of "Egyptian Irrigation." The low stages of the river are only considered in the following tables, which run from March 1st to May 15th, when there is no disturbance from flood overflows, and when there is a minimum of disturbances from freshets down the Blue Nile or the Saubat. The real low supply of the Nile is well indicated by a gauge of 10·00 at Khartum and under. The Khartum gauge is the bed rock of all information on the Upper Nile to-day. Its readings should be jealously guarded.

(7) The gauges are taken from the Government records and are referred to the discharge tables without any correction for scour or silting. Malakal is the all-round best discharge site on the Nile; and Sennar, after low floods, is an excellent site, as down stream of it is a bar of hard material across the bed of the river which prevents scour. Khartum is not such a good site as Sennar, as the difference between the volumes of the Blue and White Niles in flood affect the extent of silt deposit. Like Sennar it cannot scour below the level of the bar across the river downstream of it. Wadi Halfa is a poor gauge site and liable to both silt and scour. Figures given on page 11 show that in low years the differences between Khartum (a very fairly good gauge in low summer) and Halfa may amount to + ·29 in very poor floods and — ·18 in others. In a series of years they neutralise each other. This is well proved by the fact that the means from Halfa and Khartum gauges in the low years before and after 1914 are practically identical. It is well known that these two gauges have so far remained unaltered since they were erected.

With the exception of Khartum and Wadi Halfa, whose mean gauges and mean differences have remained practically constant, the means of all the other gauges seem to belong to different worlds, according as they are before or after 1914. I compare the differences in many ways in tabular form, and diagrammatically. (See table epitomised from Table D.)

(8) I checked these figures by comparing in Tamaniat the means of the minimum gauges in the low years before and after 1914, and again the differences were startling.

(9) Table E gives some interesting results. The mean loss in the low years before 1914, between the joint discharges of the Blue and White Niles at their heads and Khartum, is 70 cumsecs, and between Khartum and Halfa 80 cumsecs, or 150 in all. These figures can only be exceeded in years of very low supply like 1900 or 1914, when the troughs of the rivers are greatly depleted and evaporation and water consumption have full play. In such years I calculate that the differences may amount to 90 and 100 cubic metres respectively, or 190 in all.

(10) The mean differences between the discharges of the Blue and White Niles combined and Khartum before 1914 is 71, and after 1914 is 171. The mean differences between the discharges of the Blue and White Niles combined and Halfa before 1914 is 150, and after 1914 is 239. And during these identical periods the mean differences between Khartum and Halfa before 1914 is 79, and after 1914 is 68, or very nearly the same.

(11) The differences between the Sennar and Malakal gauges in 1913 and 1919 are very considerable, while the Khartum gauges in these two years are almost identical.

Cairo, 6/5/20.

(Signed) W. WILLCOCKS.

EPITOMISED FROM TABLE D.

The mean gauges and discharges of the White, Blue and Main Niles at low water for the low years before 1914 (including 1914) compared with those after 1914. The discharges are referred to the gauge tables without correction for scour, as in a series of years the scour of some of the years neutralises the silting of the others. This is confirmed by the mean of the Khartum and Halfa gauges.

	Before 1914.	After 1914.	Differ- ence.
<i>Gauges.</i>			
Difference between Khartum and Tamaniat gauges at low water.	—·04	+·20	·24
„ „ Malakal and Halfa gauges at low water .	—·05	—·35	·30
„ „ Malakal and Khartum gauges at low water.	—·06	—·37	·31
<i>Discharges.</i>			
„ „ Malakal and Halfa discharges at low water .	—45	—103	68
„ „ Malakal and Khartum discharges at low water .	+45	—25	70
„ „ joint Malakal and Sennar discharges at low water .	607	783	176
„ „ (Malakal and Sennar) and Khartum discharges at low water .	—46	—221	175
„ „ (Malakal and Sennar) and Halfa discharges at low water .	—138	—299	161
<i>Gauges.</i>			
Khartum gauges before and after 1914	9·82	9·83	+·01
Halfa gauges before and after 1914 (gauges + 8·70).	9·84	9·87	+·03
Difference between Khartum and Halfa gauges before and after 1914	+·02	+·04	+·02
<i>Discharges.</i>			
Khartum discharges before and after 1914	561	562	+ 1
Halfa discharges before and after 1914	469	484	+15
Difference between Khartum and Halfa discharges before and after 1914	94	78	+16

" N.B.—The means of the gauges and discharges of the years before and after 1914 are practically identical at Khartum and Wadi Halfa. They show that the mean flow at low water was practically the same at these two unaltered gauges in the years before and after 1914. The means however of these gauges and discharges compared with the means of the gauges and discharges of the Blue and White Niles show extraordinary differences.

TABLE E.—YEARS OF LOW SUMMER SUPPLY.

The lowest gauge readings and discharges at Khartum and Halfa, compared with the corresponding gauges and discharges at Malakal and Sennar, allowing for the time of water travel on the White and Blue Niles. See para. 7.

Year.	Khartum.			Wadi Halfa.			Discharges.		
	Date.	Gauge.	Dis-charge.	Date.	Gauge.	Dis-charge.	Mala- kal.	Sennar.	Blue and White Niles.
1908	May 9	9.81	555	May 27	1.05	434	528	64	592
1912	„ 14	9.76	530	June 8	.98	411	484	92	576
1913	April 25	9.78	540	May 13	1.07	441	520	83	603
1914	June 1	9.43	372	June 21	.86	373	461	30	491
Mean			494			415	498	67	565
Mean loss	Blue and White Niles and Khar- tum		71	Blue and White Niles and Halfa		150	Khartum and Halfa		79
			Say 70			150			80
1915	May 1—5	9.64	470	May 16—20	.96	404	502	132	634
1916	„ 11—15	9.62	460	„ 26—31	.74	331	482	71	553
1919	„ 22	9.61	455	June 7	1.11	454	582	81	669
1920	April 14	9.70	500	May 1	1.02	424	566	150	716
(to latest date)			471			403	533	109	642
Mean loss	Blue and White Niles and Khar- tum		171	Blue and White Niles and Halfa		239	Khartum and Halfa		68
			Say 170			240			70
							Before 1914.	After 1914.	Difference.
Difference between Blue and White Niles and Khartum . . .							71	171	+100
„ „ „ „ „ and Halfa . . .							150	239	+ 89
„ „ Khartum and Halfa . . .							79	68	— 11

Here the difference between Khartum and Halfa is small, but between the Blue and White Niles and the Main Nile there is a great difference.

CHARGE No. 6.

The discharges for the Nile at Aswan on page 5 of " Nile Control " for 1889, one of the years I know intimately on the Nile, and also one of the years included in the series of five years for which the Aswan discharge table of 1894 was built up, are grossly exaggerated.

I give full details of how my figures are obtained, and add that the table used is the 1894 Aswan discharge table given on page 89 of " Nile Projects." The Public Works Ministry is asked to give similar full details, and also a *copy of the discharge table they used, running from 84.00 to 92.00 on the Aswan gauge*, so that they may let the public know how they get their figures. This table will also be useful for checking their figures for 1877—78 and 1899—1900, which I have in hand.

Cairo, 8/5/20.

(Signed) W. WILLCOCKS.

" Nile Control," July to December, 1888 . . . 56,000 millions.

" Nile Control," January to June, 1889 . . . 12,000 ,,

My calculation, 56,500,000,000.

My calculation, 7,200,000,000.

CHARGE No. 7.

The present-day areas assumed for Egypt on page 23 of " Nile Control " are incorrect. According to figures supplied by the Ministry of Finance, the tax-paying area of—

Lower Egypt is . . . 3,328,000 feddans,
and of Upper Egypt is . . . 2,226,000 ,,

or 5,554,000, and not 5,300,000.

(I note as a curiosity that this area is given as 5,200,000 on page 11.)

Of this area 1,000,000 feddans are under basin irrigation and the rest are perennial.

Applying the correct figures to the table on page 23, the present-day requirements of Egypt work out to 35,300,000,000 cubic metres and not 33 milliards.

From page 5 of " Nile Control " we see that in a year like 1913—14 the Nile is credited with 41 milliards. This leaves less than 6 milliards for navigation, sanitation and potable drinking water for towns. The real surplus is absolutely zero.

From the imaginary surplus it is proposed, on page 72 of " Nile Control," to take 7.37 milliards from the river when it has not a drop to spare, store it in the White Nile Reservoir, lose 3.98 milliards by evaporation and absorption, and hand back 3.39 milliards to the Sudan and Egypt.

Now I prove on pages 128 and 129 of " Nile Projects," that, with cotton at £4 per cwt., 1 cubic metre per second from December 1st to June 1st in a low year is worth at Malakal £150,000. This means £10,000 per million cubic metres, or £10,000,000 per milliard of cubic metres. The water proposed to be wasted in the White Nile Reservoir would be worth £40,000,000.

No project which contemplated such waste would be worthy of serious consideration if it had no competitors, but this one has serious competitors, which either use water running to waste to-day or store with no loss to speak of water worth tens of millions of pounds.

Cairo, 14/5/20.

(Signed) W. WILLCOCKS.

CHARGE No. 8.

(1) As an Egyptian taxpayer I protest against the leaving out of the White Nile project any estimate of cost. It is unheard of in the history of projects. Egypt is asked to undertake a work without having the faintest idea of its probable cost. It was ten years ago that the project began to be worked at, and eight years since the site was fixed upon, and yet :—

- (1) On the unnumbered plate giving the longitudinal section of the dam there is no definite foundation level. We have only "*assumed rock surface.*" One would think we had before us the preliminary project of 1912.
- (2) On page 74 are mentioned the great advantages to the White Nile provinces and the extra wealth which will ensue from drowning out the inhabitants of the province, their dwellings and their lands ; but when I was there in 1918, they were estimating the heavy compensation which Egypt would be called upon to pay for lands, dwellings, young forest and goodwill, on some 600,000 acres and villages and towns.
- (3) Much money has already been spent on survey levels, buildings and contingent works of which no account whatever is given.
- (4) No estimates of—
 - (a) Quantities of different classes of work.
 - (b) Area of land for which compensation will have to be paid.
 - (c) Extent of houses, markets and market places which will be displaced.
 - (d) The cost of raising the Kosti bridge and railway above the reservoir level.
 - (e) Contingent works.
 - (f) Number of years the work will take to complete.

2. As an Egyptian taxpayer I protest against the execution of a work which would put it in the power of any Sudan Government to cut off Egypt's water supply for six months at a time and make Egypt pay heavily for any water passed on, if it passed any on.

Cairo, 14/5/20.

(Signed) W. WILLCOCKS.

CHARGE No. 9.

THE WHITE NILE PROJECT, CONTINUED FROM CHARGES NOS. 6, 7 AND 8.

In this charge, I tabulate the patent errors which have intruded themselves during my rapid examination of " Nile Control " up to page 77 :—

- (1) " Nile Control," page 5.

For 1899—1900 the July to December discharge is 48,600 and the January to June 6,000 million cubic metres.*

For 1913—14 the July to December discharge is 34,600 and the January to June 6,200 million cubic metres.

For 1888—89 the July to December discharge is 56,500 and the January to June 7,200 million cubic metres.

For 1877—78 the July to December discharge is 57,800 and the January to June 8,400.

I have not examined the others.

The January to June present-day requirements of Egypt are given as 11,000, which are greatly in excess of actual available figures with the Aswan Reservoir added. The figures in the report are grotesque.

- (2) The "*flood*" does not last from July to December, nor the "*summer*" from January to June.

* The calculated discharges on page 5 contradict Sir Hanbury Brown's figures for 1900.

(3) Page 19. The calculations for losses in the canals are valueless. They are pure guesswork.

(4) Through the report, the areas irrigated are assumed as secured. No count has been taken of the tens of thousands of acres ploughed up and re-sown with flood crops in years of poor supply.

(5) Time and space has been wasted on an imaginary 7,100,000 acres under crops in Egypt to the neglect of the present-day area, which is of supreme importance. To be of any practical value the tables on pages 24, 27 and 34 should be re-cast for the existing 5,554,000 acres of tax-paying land.

(6) To enable the engineer to grasp the situation, the gauges at, and discharges passing, the Esna, Naga Hamadi, Assiout and the Delta Barrages should be given in ten-day periods for 1913—14 and 1899—1900, assuming the Blue and White Nile dams in full working order, the Aswan Reservoir being filled and emptied, and the Naga Hamadi Barrage working with the others. I am sure it will be found that none of the barrages on the Nile could stand (without falling flat) the heads put on them to secure irrigation, especially basin irrigation. Until these figures are supplied, ten-day by ten-day, as is the rule in Egypt, all serious examination of the effects of the new Nile works is absolutely impossible. And it must not be forgotten, as Sir Murdoch MacDonald seems to have done in his calculations of water available for withdrawal, that South Australia has, in the Federal Courts, upheld her navigation rights on the Darling and prevented New South Wales withdrawing its water for irrigation. Where are the South Australian navigation rights compared with Egypt's immemorial rights, going back thousands of years? This is said in no spirit of churlishness but only of fair play. New South Wales is craving for irrigation like the Sudan.

(7) I note in passing that Sir Murdoch MacDonald has a poor memory when he sits down to write what he calls history. He forgets that—

- (1) I proposed the Aswan Reservoir and Dam, 1894 (page 43, para. 1).
- (2) I pushed raising the Aswan Dam against all its competitors, 1903 (para. 6).
- (3) I proposed in 1908 the White Nile Reservoir for irrigation and Nile protection as preferable to Sir William Garstin's Sudd proposals (page 44, para. 7). The last paragraph of page 44 is taken practically word for word from me.
- (4) Mr. Craig and I proposed using a low level White Nile Reservoir and a raised Aswan Reservoir in 1912—a project ten times as sound as the present one, which is another modification of mine (page 45, last paragraph).
- (5) The first paragraph of page 46 is imagination. Lord Kitchener in 1913 openly said that he could not recommend the White Nile Reservoir for water storage the day the raised Aswan Dam began functioning; it was more decent to put "flood protection" in the foreground.
- (6) Paragraphs 3, 4 and 5 are practically from my lectures of 1908, and the last paragraph, too, if "from 4 to 5 metres" is changed to "from 3 to 4 metres." (I shall re-read my lectures at my leisure.)
- (7) The idea of completing the basin conversion of Upper Egypt and delaying the land reclamation before any storage can be seriously undertaken on the Nile is entirely mine (page 50, paras. 1 and 2).

While on the subject of history, I may say that there is another lapse of memory on Sir Murdoch MacDonald's part on page 36, when he forgets that I took hundreds of discharges of the Nile between 1889 and 1894, and made the Aswan discharge table which is used till to-day by the Public Works Ministry whenever they are at a loss for a figure. It was only when that Ministry got hold of a sufficient number of discharges stolen from me that they began to take credit to themselves for what I had done. Simultaneously, the eighty discharges of mine which the Ministry had disappeared off the face of the earth. "*Sic transit gloria mundi*."

(8) Mr. John Wells and I put in the first serious project for the Sudd Region when we saw, in the flood of 1918, what an infernal nuisance the White Nile Reservoir would

be. Why did not Sir Murdoch MacDonald quote Dr. Chalmers after the flood of 1918 opened our eyes, and why did he only quote a saying of his predecessor, Dr. Balfour, written many years before ?

(9) When the Government puts its information about the effects of the proposed reservoir into ten-day periodical information I can criticise the tables. It is impossible to-day.

(10) I protest strongly against bringing in the *discredited Tamaniat gauge* which has disappeared and whose readings are called "doubtful" by the Government engineers themselves. Everything should be referred to Khartum. No reliance can be placed on any figures referred to Tamaniat. It is possible that it is used instead of Khartum as the Khartum gauge *proves* that the gauges on the Blue and White Niles have been lowered, while the discredited Tamaniat gauge helps to conceal the fact. I note in passing that the Tamaniat gauge and discharge for 1919 is the only information I have seen given for 1919 in "Nile Control." The Khartum gauges for 1919 are not given in "Nile Control." They would be damning if put together.

(11) The table on page 65 is an engineering curiosity. Sir Murdoch MacDonald seems to think that the Damietta and Rosetta branches could be dried in flood. This is the only conclusion which can be drawn from column (5). Where does the Aswan Reservoir filling come in ?

(12) The contents and water supply of the Aswan Reservoir are exaggerated.

(13) Pages 74 and 75 are an extraordinary distortion of the truth. No human beings except ash and cow-dung smeared savages could live among the malarial mosquitoes which I saw breeding in millions along the water's edge in 1918. Why did not Sir Murdoch MacDonald answer my criticism in "Nile Projects" which I here attach ? * When I came back to Khartum from my journey on the White Nile in 1918 I went straight to Dr. Chalmers, the head of the Wellcome Tropical Disease Research Section of the Gordon College, and told him of what I had seen. He was horrified and said he would write straight away to the Governor-General. Why was he not consulted by Sir Murdoch MacDonald, who never even took the trouble to go and see the White Nile acting as a reservoir ? He dared not go. He preferred staying in Cairo and contradicting the statements of men who took the trouble to carefully examine everything on the spot.

(14) The calculated losses for evaporation are considerably less than the 15 mm. per day recommended by Mr. Craig. Mr. Craig's figures would increase the losses by about 1 milliard and reduce the assets by the same amount.

(15) I have read to the last page of the White Nile Reservoir Project, criticised it in the gross in Charges Nos. 7 and 8, and await the ten-day figures to criticise it in detail.

(16) I stand by everything I have said on this subject in "Nile Projects" and in the blue and orange pamphlets.

15/5/20.

(Signed) W. WILLCOCKS.

* Page 66 of "Nile Projects." Add under "C" :—"Sir William Willcocks' reply : The Committee, in its para. 48, wisely shelters itself under something written by Dr. Balfour in 1911 before the extraordinary winter and spring flood of 1917—18 had shown how great a danger to the public health a reservoir on the White Nile would be. They took care to avoid consulting Dr. Balfour's successor, who had knowledge of what a maintained high supply on the White Nile through the winter means to the Sudan. The last recorded flood of this description was in 1878—79, and was known in the Sudan as the Sanat-el-Bayouda, or mosquito year. The extraordinary flood of 1917—18 explained to us the reason why this name was given. Dr. Balfour in 1911 thought, as we all did, that the mosquitoes came from stagnant pools, but 1917—18 taught us that mosquitoes are bred through the winter in the vegetation everywhere along the water's edge. The vegetation was there because the water did not speedily fall, as it does in ordinary years, and the stuff which floated out of the Sudd region took root and flourished."

CHARGE No. 10.

THE BLUE NILE PROJECT.

(1) Charges Nos. 1, 3 and 4 have had to do with the unreliability of the data on which the project is founded.

(2) I protest against 1913—14 being treated as a year apart. The year 1899—1900 was as bad, if not worse. The fact is concealed by the Khartum gauge being recorded 22 cm. higher than it really was.

(3) The Public Works Ministry has evaded calculating the amount of checking the velocity of the Blue Nile will receive upstream of the dam as the flood rises in July, and its very muddy waters cannot go on without parting with their mud. I call upon them to give these figures as the river rises from R.L. 406·00 (downstream) to 417·20, for R.L. 406, 409, 412, 415 and 417·20, and even 420·20. This is a very important issue as far as Egypt is concerned, and has been entirely evaded.

(4) It is absurd to imagine that in low years like 1899—1900 and 1913—14 and others, when the monsoon rainfall is poor or has failed, that the inhabitants of the Gezireh will refrain from taking water for their durra. They will take it by force if not by goodwill. The quantity of water which will be taken will be measured by the capacity of the canal, which capacity is hidden from Egypt.

(5) I protest against the cross-sections of the canal, its longitudinal section and discharging capacity being hidden from Egypt. The whole project is not an effort to give information but to withhold it. I ask the Public Works Ministry to produce every detail of the canal, so that we may know how much the canal can carry. It will be in deep digging probably for a long distance and will be able to be fed by the river held up to reservoir level. The concealment of information and the changing of the gauges on the river justifies Egypt in not taking anything on trust in the Sudan projects.

(6) As the Aswan Reservoir has first claim on using clear water for storage, I protest against any water being withdrawn from the river at its time of filling. The last paragraph on page 87 is absolutely incompatible with Egypt's claims.

(7) Egypt has full and absolute claims on the water in the Blue Nile as it rises in May, June and July beyond what she has allowed the Sudan to take. The rich red water of the early flood is her heritage and she cannot be deprived of it without her consent being obtained. This project rides rough-shod over her rights.

(8) The Sudan has tens of millions of acres of good land, with plentiful and timely rainfall, for securing the best Egyptian and American cotton and summer cereals ; but the land lies a barren waste, as far as human beings are concerned, because the soil is of such a character that it has no ground water even for drinking purposes. The absence of drinking water is the cause of the undeveloped character of the country. One project for the development of the Sudan without infringing on Egypt's rights is to make drinking water canals for men and animals and let the rainfall do the irrigation.

(9) If the Sudan insists on irrigation in winter and early summer, and Egypt insists on her claims on the rich red muddy water of the early flood (Egypt is the gift of the Nile), the working solution for the Sudan is to erect powerful pumps on the Blue Nile and irrigate cotton. These pumps are working very successfully to-day and the company working them is making a big profit. This is a solution which will not clash with Egypt's rights.

(10) But why should the Sudan at this stage of her development want winter and summer irrigation ? Egyptian and American cotton can be grown, as was proved in 1912, with basin irrigation. This is the time of the year there is, as a rule, water available, and a system of irrigation practised in Bundelkund, in India, would secure both cereals and cotton. Leguminous crops could be grown with both cotton and cereals and provide them with nitrogen. I give a plan illustrating what I say.

(11) When the Gezireh project was started in 1911—12 the Inspector-General of Irrigation in the Sudan asked me to show his staff how to start the designs for the dam and the main canal. I showed them what data to collect and designed the main canal for them and a cheap dam, for Lord Kitchener wanted everything for the Sudan to be economically done. The dam now shown is, to my way of thinking, unnecessarily expensive. The main channel of the river should be closed with an earthen dam of the type Nimrod made on the Tigris, and which the muddy deposit of the river turned into a fortress. The masonry dam would be built entirely in the dry. I speak solely as an engineer interested in an engineering problem.

(12) I protest against any escape from the Blue Nile into the White Nile. My reasons have been often given. Three years on the Tigris and Euphrates, where such escapes exist, cured me for ever of wishing to see them repeated anywhere. I confirm every word I have said on this subject in " Nile Projects " or the pamphlets.

Cairo, 15/5/20.

(Signed) W. WILLCOCKS.

CHARGE No. 11.

THE APPENDICES.

(Continued from Charges Nos. 1, 2, 3, 4 and 5.)

I complete my criticism of Part VIII. of " Nile Control."

(1) The statements made on pages 141 and 142 are a confession of impotence. It is not due to any fault in the science of hydraulics that since 1918 the Physical Service of the Public Works Ministry has had to give up using, for the first time in Egypt, well-established discharge tables which have had applied to them corrections for scour and silt. Utterly unable to use the tables with the reported gauges unless corrections were applied to the current-meter, I assumed, with Mr. Craig, that the current-meter observations needed corrections of from 10 to 15 per cent. It was only late in February of this year that I recognised that it was the gauges which needed correction. I have explained this fully in Charges Nos. 3 and 4, and shown how everything falls into place once the changes in the gauges are made.

(2) The above refers to sound observations like the discharges taken at Halfa in 1912, which, unfortunately, are left out of " Nile Control." They do not refer to unsound observations. Such unsound observations are: (1) Those given for Halfa in 1914, where the names of the observers are omitted as well as the corrections which were applied. (2) The Mogren in 1914 and 1919 (I have not examined the others). These two are quite unreliable. (3) Soba in 1914 and 1919. (4) Malakal in 1919. I shall give details of this very serious unreliability later.

(3) I protest against the Malakal ten-day means for 1914 and 1916. The first is always 10 cumsecs above and the other below the table; while the Malakal discharge for May 21st—31st, 1914, is increased by 50 instead of by 10 cumsecs as the others are. If it had not been raised, the Mogren ten-day means corresponding to the discharges would have shown more water at the tail of the White Nile than at its head in the height of a low summer! The Khartum gauge meanwhile had been showing heavy losses.

(4) The Mogren discharges for 1919 are very unreliable. In May and June they show practically no loss on Malakal, and at the end of May they rise with the rising gauge, though the gauge is rising owing to heavy supplies coming down the Blue Nile and throwing back water on to the White Nile which must have been diminishing the discharge and not increasing it. Soba and Mogren together show discharges which throw ridicule on the Khartum and Halfa discharges or *vice versa*.

(5) In the series of discharges beginning page 237, there are extraordinary contradictions between similar years if we compare: (1) Malakal with Mogren; (2) Malakal and Sennar with Khartum; (3) Malakal and Sennar with Halfa; (4) Mogren and Soba with Khartum, Tamaniat and Halfa.

The gauges and discharges given me for the White and Blue Niles and Khartum for 1919 are extraordinary documents. In 1916 they took no discharges on the Blue Nile, while 1917 and 1918 were extraordinarily high, and it is 1919 and 1920 which disclose the real unreliability of the published gauges and those given daily to-day to the public. I shall hand in a special report on these irregularities later. This will be in continuation of Charge No. 4.

The Public Works Ministry should apply at once ten-daily gauges and discharges for 1919 from January to June for Malakal, Sennar, Soba, Mogren, Khartum (gauges only), Tamaniat, Halfa, and Aswan, and a table of Aswan emptying for 1919.

Appendix VI.—Transit losses can only be compared if the times of water travel are carefully recorded.

Page 252.—In whatever shape you see 1914 it is always higher than anything else. It is an “*annus mirabilis*” for high flights.

Page 256.—Though the revision of the figures for 1914 lead to unimportant corrections, it is strange that similar revisions applied to 1912 (in the same way) lead to important corrections. They even lead, as they do in some of the years, to silting of the gauges with the clear water of the reservoir in summer; and this on a discharge table of which Sir Murdoch MacDonald said: “The new table is compiled from “observations made in 1901 and 1902 . . . *adjusted by subsequent knowledge of sluice “discharges,”* and of which Mr. Hurst said: “We all assisted in the elaboration of these “proofs and know them to be true and convincing.” How you can have silting in June with clear reservoir water is a mystery.

Page 257.—The concordance of discharges in 1914 is discord.

Appendices VIII., IX. and X. will all be included in the special examination of 1914, 1916 and 1919 already promised. Egypt is standing on a quicksand, as far as its knowledge of the Nile goes, from information given daily to the public and supplied in “Nile Control.”

Page 178.—The Khartum gauges for 1900 are wrongly recorded; every low gauge is 22 cm. too high. The real minimum was 9.30 and the minimum for 1914 was 9.43.

Cairo, 15/5/20.

(Signed) W. WILLCOCKS.

CHARGE No. 12.

(1) The proposed Lake Albert Reservoir (page 127).

In the very dry February of 1908, when I crossed the Victoria Nile at the Pajao Ferry, downstream of the Murchison Falls, it seemed to me that I was traversing a stream twice as powerful as the Albert Nile or the Bahr el Gebel just upstream of the Fola Rapids at Nimule, where I had spent a couple of days a short time before. The loss by evaporation of Lake Albert Nyanza and the Albert Nile was so excessive that it greatly exceeded the discharges of the Semliki and the other tributary streams of the Albert Nile. This fact militated against the use of Lake Albert as a storage reservoir for the Nile; but the absolute condemnation of Lake Albert as a reservoir never occurred to me until I read quite recently a report by Mr. Grabham, the Sudan geologist, to which Kennedy Pasha called my attention. Mr. Grabham holds that the river issuing from Lake Albert flowed once at a much lower level than it does to-day and that all the tributary streams flowed into it like torrents. There then occurred an upheaval of the granite at the head of the Fola Rapids and the surface of the water may have been raised from 10 to 12 metres, and the Albert Nile became like a "Norfolk Broad," wasting water from its extended surface. The valley was drowned out and all the tributary streams began forming deltas in the "broad," where they dropped all the deposit they carried. He states that upstream of the Fola Rapids the river to-day is in places over 12 metres deep, a depth which could in no way have been scoured out. He suggests that the true project for getting water from the upper reaches of the Nile is to lower the abrupt crest of the Fola Rapids by 40 feet (12 metres) and dry the "broad" upstream of it, and let all the water travel north as quickly as possible. This water would find itself in the Sudd Region Reservoir and be ready for transportation to Egypt the day the Zeraf River escape began acting. It is a fascinating study and full of potentialities for Egypt and the Sudan.*

(2) The Sudd Region Reservoir has been fully described in the two lectures printed in "Nile Projects." It constitutes the one workable reservoir which adds to the discharge of the river without taking anything out of it. In the very low years, when there is no water to spare except on paper, the project is hard to beat. It is the real riddle of the Egyptian Sphinx, and hard to solve; but, once solved, it lands us in finality. Aided by the waters south of the Fola Rapids, it will be still more effective, while its economy of water will be greatly increased by the raised Aswan Reservoir.

(3) The raised Aswan Reservoir has been fully explained on pages 169 to 172 of "Nile Projects," and I have nothing to add. When, in years like 1900 and 1914, the White Nile Reservoir would have wasted four milliards of cubic metres on paper and five milliards in reality, the raised Aswan Reservoir would have wasted one-tenth of a milliard. It would have saved water worth tens of millions sterling (page 259).

(4) While working for months at the discharges of the Upper Nile, there was one fact which struck me again and again, and that was that the Halfa discharge, as the summer went on, fell less rapidly than that at Khartum. I said to myself this must be due to the fact that the pools above the cataracts are being drawn upon like so many little reservoirs. Now if the crests of these cataracts were brought up to a standard level, and a few under-sluices and deep open slits (open to the bottom and narrow) added, an amount of water would be impounded which could be discharged simultaneously and keep the existing Aswan Reservoir at full level to the end of June. Their insignificant height would ensure the pools above them from being silted, while the under-sluices and open narrow slits (as in the old Hindia Barrage on the Euphrates †) would drain the pools deep.

(5) These works would be all founded on rock and constructed of big pitching blocks of stone on the downstream side, middle blocks in the middle, and small pitching

* The Victoria Nile enters, and almost immediately leaves, Lake Albert at its north end. A bank thrown up by dredgers between the lake and the Victoria Nile (if economically feasible) would economise 400 cumsecs in the dry months. Lake Albert is 4,500 square kilometres in extent, and in the dry months must evaporate some 500 cumsecs. It might even be used as an escape.

† The old Hindia Barrage is founded on clay at a site chosen by Alexander the Great, because he said the clay was hard.

upstream like the old Hindia Barrage on the Euphrates. Like the old Hindia Barrage, they would be staunches solid with Nile mud and become as impermeable as masonry. The cataracts could be closed as readily as we closed the breach in the old Hindia Barrage, and in the method shown opposite page 720 of "Egyptian Irrigation." It was extraordinarily cheap and extraordinarily effective. All that would be finally needed would be a solid crest of masonry 1 metre thick on the top of the rubble dam. In this way, between Abu Hamid and Halfa enough water could be stored in flood to meet all Egypt's requirements. The rapids could be taken up at the rate of one per annum, and that would meet year by year the growing requirements of Egypt. And if the frontier of Egypt were fixed at Abu Hamid, Egypt, with its cataracts and Aswan Reservoir, would be a self-contained unit on the Nile. I have been late in seeing this, but it has many attractions, especially as it would make Egypt independent of the Sudan.*

(6) In imitation of Lord Cromer's way of working, the Agricultural Ministry and the Public Health Department should, I suggest, be fully consulted before any decision is come to.

Cairo, 15/5/20.

(Signed) W. WILLCOCKS.

* It is not improbable that the well-maintained depth of water in the Egyptian Nile throughout the summer in ancient times, which, as affirmed by archæologists, permitted of the transport of huge monoliths from Aswan to the sea throughout the year, may well have been due to the fact that the cataracts were much less degraded then than what they are to-day. We know from flood marks, extending over many years, on the rocks at the Semne Cataract, that 4,000 years ago the flood attained a height of 7 metres over what is possible to-day.

At the Garni head of the Nahrwan Canal the Tigris has fallen over 10 metres within the last 1,000 years. This was due to the undermining of Nimrod's dam, which had stood for thousands of years. The abandoned Nahrwan Canal, north-east of Bagdad, is 400 feet wide and 15 feet deep. Its spoil banks are called "hills" by Gibbon, and it was sheltered behind these that the Persian archers destroyed the Roman army under the Emperor Julian in person (his grave is there to-day), and, about 400 A.D., put an end to the Far Eastern Roman Empire for ever.

CHARGES BROUGHT BY COLONEL KENNEDY.

No. 1.—I accuse Sir Murdoch MacDonald of falsifying the gauge readings for Sennar for the period 11/1/14 to 20/1/14. The proofs of this are contained in the original Blue Nile Memorandum (*vide* para. 8 of "Bulletin No. 2"). That memorandum can be produced at a moment's notice from the official archives of the Public Works Ministry. The true figure is 10·19. The forged figure is 10·28.

No. 2.—I accuse Sir Murdoch MacDonald of falsifying the gauge readings for Sennar for the period 21/1/14 to 31/1/14. The proofs of this are contained in the original Blue Nile Memorandum (*vide* para. 8 of "Bulletin No. 2"). The true figure is 10·09. The forged figure is 10·17.

No. 3.—I accuse Sir Murdoch MacDonald of falsifying the Sennar gauge reading for 24/1/14 from its correct figure, namely, 10·10, to its present forged figure, namely, 10·20. I lay particular stress on this charge as it is one that admits of immediate proof.

No. 4.—I accuse Sir Murdoch MacDonald of deliberately publishing false figures for the discharges at Aswan (*vide* page 11 of the Annual Report for 1912). The true figures are contained in the printed but suppressed portion of that Report, page 195. They are also given in the photographic copy of the original calculations for the White Nile Dam forwarded by me to Sir Paul Harvey on 24/11/19.

If Sir Murdoch MacDonald desires to deny this latter charge, let him produce the emptying table for Aswan Reservoir for 1912, a copy of which is given on page 94 of Sir William Willcocks' publication "Nile Projects."

No. 5.—I accuse Sir Murdoch MacDonald of deliberately framing a false record or writing—to wit, his Note dated November 25th, 1916—knowing he would thereby cause loss or injury to the public.

In that official Note he states: "The available volume is 65 metres cube, to which the river has been known to drop only once in 150 years. Obviously there is enough water for cotton in these very worst of circumstances, as it takes 58 metres cube only."

The official Note in question was written by Sir Murdoch MacDonald one week after my interview with him on November 19th, 1916, when I showed him the official records disproving his statement.

The official truth, as opposed to Sir Murdoch MacDonald's false statement, is that the lowest actual discharge officially taken during the critical period was 45 metres cube per second, or, in other words, Sir Murdoch MacDonald falsified the official discharges to the extent of nearly 50 per cent. A certified true copy of 1914 discharges as officially taken constitutes my proof of the above charge.

No. 6.—I accuse Sir Murdoch MacDonald of attempting to justify the Gezira irrigation scheme by means of a document, signed by him over date May 20th, 1917, of which every original line is either a falsification or is grossly inaccurate in the face of the official facts and records.

Sir Murdoch MacDonald framed that document knowing it to be false and incorrect, and knowing it to be likely to cause loss or injury to the public.

No. 7.—I accuse Sir Murdoch MacDonald of *deliberately* publishing false readings of Khartum nilometer for the record low summer supply year, namely, 1900.

**Formal Reply of Ministry of Public Works to Charges brought by
Sir William Willcocks, K.C.M.G.**

As to Charge No. 1, the Ministry denies that the Blue Nile gauges at Sennar were altered between the dates alleged or at all.

The Ministry denies that the discharge of the river in the said interval was exaggerated.

The Ministry denies that the said document was a public document or that it was of prime importance.

As to Charge No. 2, the Ministry denies that the figures for the discharge of the Nile published in the 1912 Report were false, and denies the loss of the said public document.

As to Charge No. 3, the Ministry denies that the discharge of the Nile as measured by sluices at Aswan for the low months of 1916 is exaggerated.

As to Charge No. 4, the Ministry denies that the new Sennar gauge on the Blue Nile has been lowered by 35 cm. or at all.

As to Charge No. 5, the Ministry denies that the recorded gauge readings of the Blue or White Nile after 1914 are inconsistent with such gauge readings before 1914.

The Ministry denies that there is any necessary correlation between gauge readings and discharges.

The Ministry admits that no discharges whatever were taken at Halfa through 1915, 1916, 1917, 1918 and 1919, and says that this was on account of the absence of many officials during that period.

The Ministry admits that the values of bench marks and the reduced levels of the zeros of gauges were altered, and says that this was done for uniformity and to make them precise.

The Ministry admits that during the said period complete gauges and discharges were not given to the public, and says that this was not done partly because of an order of the Council of Ministers to that effect and partly because of the war which was being waged during that period.

The Ministry denies that there was any conspiracy to bewilder or confuse.

As to Charge No. 6, the Ministry denies that the discharges for the Nile at Aswan for 1889 have been exaggerated.

20/5/20.

(Signed) F. M. MAXWELL.

Extracts from Pamphlet containing Criticisms submitted by Abdullah Pasha Wahbi and the Committee of Egyptian Engineers.

CRITICISM 1.

The Adviser has considered that the cultivated area, in Egypt, from the present time until 1925, will be 5,200,000 fed. (see p. 11, Nile Control Book). In 1916–1917 the cultivated area is estimated at about 5,320,000 fed. (see p. 12). In 1914 the taxed area in Egypt amounted to 5,633,054 fed., and this area will naturally attain a higher figure in 1925, as shown in the introduction of the “Nile Almanac “Book” by Amin Pasha Samy.

The present taxed area in Egypt should, from a technical point of view, be recognised as a basis in calculating the volume of irrigation water required. If we reckon the taxed area in Egypt to be 5,633,054 fed., this volume at present will be, according to the Adviser's calculations :

34	milliards c.m. to irrigate 5,200,000 feddans.	
	(See p. 2.)	
3.050	” ”	to irrigate the deficit of 433,000 fed. in the area calculated by the Adviser; for in his Report he stated that 50 millions are sufficient to irrigate 7,100,000 fed. (See p. 4, Arabic).
2	” ”	of water should be discharged into the Nile during January for navigation. (See p. 128, Sir M. MacDonald's Nile Control Note, English copy, p. 8.)
3	” ”	should be discharged into the sea to prevent the rising of the Nile bed. (See p. 15, Sir M. MacDonald's Nile Control Note, Arabic copy.) Sirry Pasha has considered this amount to be 5 millions.

42.050

Thus Egypt is at present in need of the 41 millions, or the whole water supply of a year like 1913–1914. (See p. 64, Sir M. MacDonald's Report.)

We have observed that the Gebel Aulia Reservoir will, on being used, cause a loss of 4 millions c.m. of water through absorption and evaporation. (See p. 49, Sir M. MacDonald's Report.) Its construction will not, therefore, be beneficial but detrimental to Egypt if used in a year like 1913–14 during which every drop of Nile water is badly needed. The Adviser has mentioned in his Nile Control Note (p. 8, Arabic copy) the following :—

“If, however, an abnormally low flood, such as that of 1913 should recur before provision for “storage from year to year has been provided at Lake Albert, it may not be feasible to abstract from “the river enough water to make full use of the Gebel Aulia Reservoir.”

This extract means that water stored in Gebel Aulia Reservoir at that time fails to cover the requirements of Egypt, a thing which should be carefully examined.

CRITICISM 2.

In calculating the amount of water required for Egypt, the Adviser recognised the maximum cultivated area to be 7,100,000 fed. (p. 1), but on p. 11 that amount goes up to 7,190,000 and therefore we should, from a technical point of view, say 7,200,000 and not 7,100,000 as has been given by the Adviser when considering the water required by Egypt when the whole area has been reclaimed.

CRITICISM 3.

All tables showing the work of Gebel Aulia and Makwar Reservoirs are made up with a view that Egypt's present water requirements are 35.50 millions. (See Table 15, p. 66.) If we take as correct the Ministry's figures, this amount should be 39 millions because :—

34	milliards m. c. of water are required for the present cultivated area (p. 2, Nile Control Note, English copy).
2	” ” of water should be discharged into the Nile during January for sailing purposes. (See p. 128, Nile Control Note, English copy.)
3	” ” should be discharged into the sea to prevent the rising of the Nile bed. (See p. 15, Nile Control Note, Arabic copy.)

TOTAL 39

The total is therefore 39 millions and not 35.50, as stated by the Adviser.

CRITICISM 4.

In our criticism No. 3, we showed that Egypt requires 39 milliards of water according to the Adviser's figures. The Adviser also estimated that Gebel Aulia Reservoir will cause a loss of 4 milliards of water through absorption and evaporation (p. 49, Nile Control Note, English copy).

Again he says that Gebel Aulia Reservoir will be constructed merely for the benefit of Egypt and thus Egypt's requirements of water after its construction will be, with the present cultivated area, about 43 milliards, comprising evaporation and absorption losses caused by Gebel Aulia Reservoir. If a year like 1913-14 with a water supply of 41 milliards recurs before the construction of the Upper Nile reservoirs, how then could we cover the deficiency caused by the Gebel Aulia Reservoir?

CRITICISM 5.

If we admit the accuracy of the Adviser's figures of p. 7 as regards the present cultivated area and of p. 51 as regards the volume of water required per feddan during the different periods, the water required for irrigation will be as follows:—

AREA IN FEDDANS	WATER REQ. PER FED. CUBIC M.	TOTAL AMOUNT OF WATER REQ.	
3,000,000	7,000	21	milliards Water required to irrigate Lower Egypt.
1,000,000	8,600	8.60	„ Water required to irrigate Upper Egypt under the Sefi system.
1,200,000	7,600	9.12	„ Water required to irrigate the area in Upper Egypt under Basin system.
5,200,000		38.72	„

or 39 milliards of water instead of the 34 milliards given by the Adviser, if we consider his figures regarding the area and the volume of water required per fed. to be accurate.

Again, if we add the 5 milliards c.m. which, according to the Adviser, should be lost into the sea and into the Nile for navigation, the total volume of Egypt's requirements of water under the present cultivated area will be 44 milliards and not 35.50 as is given by the Adviser.

CRITICISM 6.

After construction of Gebel Aulia and Makwar Reservoirs and before 1930, the Sudan and Egypt's requirements of water will be, according to the Adviser's figures, as follows:—

34	milliards required to irrigate the present cultivated area. (See p. 2, Nile Control Note, English copy.)
2	„ must be discharged into the Nile for navigation (p. 128, Nile Control Note, English copy).
3	„ must be discharged into the sea to prevent the rising of the Nile bed (p. 15, Arabic copy).
3.150	„ are lost by evaporation and absorption through the construction of Gebel Aulia Reservoir (p. 49: Aswan gauge).
1.600	„ required to irrigate the 300,000 feddans in the Gezira (pp. 87-88).
43.750	

The total is about 44 milliards, and this amount will not be in a year like 1913, the supply of which is 41 milliards only (p. 3, Table 1, Nile Control Note, Arabic copy). The whole Nile water supply in a year like 1913-14 will not, therefore, suffice Egypt alone assuming the Gebel Aulia Reservoir to be already constructed. (Ref. criticism No. 5.)

CRITICISM 7.

The Ministry has, through H.E. Ismail Pasha Sirry, then the Minister, said that the Nile discharges in 1913-14 were about 41 milliards, of which 11 milliards flowed uselessly into the sea. (Ref. to Sirry Pasha's Lecture.) Sir M. MacDonald, on the other hand, estimates the wasted amount to be 9 milliards only (p. 2), and no mathematical account was made in either case to show the amount discharged into the sea during 1913-14. One member of our Committee has asked the Ministry for information concerning these facts in order to be able to know the actual amount of water required for irrigation and the amount discharged into the sea, but the Ministry gave no answer, despite the extreme importance of such information.

They say that the real object of these projects is simply to store the surplus amount of flood water for summer use when the Nile supply happens to be too short to cover irrigation. Reservoirs fail to do this as regards Egypt because after their construction the lost amount of water will be as follows:—

3.150 milliards of water are lost by evaporation and absorption in Gebel Aulia Reservoir (p. 49).	
(This is calculated at Aswan.)	
3	„ should be discharged into the sea to prevent the rising of the Nile bed (p. 5, Arabic copy). This amount is considered by Sirry Pasha to be 5 milliards.
2	„ should be discharged into the Nile during January for navigation (p. 128).
1.600	„ will be taken for the Sudan irrigation purposes (pp. 87-88).
9.750	TOTAL.

That is to say, a volume of 10 milliards of water will be lost from the Nile, no benefit recurring to Egypt therefrom.

Before the construction of these two dams this amount passed on to Egypt during the flood season and this helped to make navigation easy. After the construction of these two dams 10 milliards will be lost uselessly; of these $8\frac{1}{2}$ milliards are wasted and 2 milliards are taken merely for the Sudan irrigation. Three milliards only of this amount will pass on to Egypt during the flood season and this is not sufficient to prevent the silt from being deposited in the river bed, a thing which will cause great damage.

CRITICISM 8.

The cultivated lands of Egypt are irrigated in two ways:—

- (1) The Perennial Irrigation System depends largely upon the amount of Nile water supply.
- (2) The Basin Irrigation System depends largely upon the Nile water levels. If the water level is high less danger is expected to occur and little or no lands will suffer from sharaki.

The construction of Gebel Aulia Reservoir which, from August to October, stores all White Nile waters in a year like 1913-14 (p. 50), and the fact that some of the Blue Nile water is drawn during this time to irrigate Gezira lands and to fill up Makwar Reservoir (p. 89), will affect the Nile water in years like 1899-1900, 1913-14. It would have been better for the Adviser to have drawn up tables to show the water levels in observation stations along the Nile from Aswan to the Mediterranean Sea from the beginning of August till the end of October and for periods of ten days for years like 1899-1900, 1913-14, and, assuming that Makwar and Gebel Aulia Reservoirs as well as Nagh Hamadi barrage are all built, in order that the effects of these projects be felt by all, and especially as regards the irrigation of Egypt and the particular Basin irrigation system.

CRITICISM 9.

The ultimate object of these schemes is to appropriate the Blue Nile exclusively to the irrigation of the Sudan and the White Nile for the benefit of Egypt. This appropriation will be most prejudicial to Egypt, if it will not lead to total ruin, as it will deprive the lands of the Blue Nile's red silt, which carries with it the fertilizing substances.

In support of this statement, namely, that the Blue Nile water will be devoted to the Sudan and the White Nile water to Egypt, we would quote here the opinion of great British engineers and Rulers on the matter.

1. Sir William Garstin, formerly Adviser to the Ministry of Public Works for several years, was the first to study minutely these projects and personally to take observations and Nile discharges from its source down to Khartum, a work for which he was awarded a sum of L.E. 15,000 granted by the Egyptian Government in compensation for the hardships he sustained while in Abyssinia. He wrote a book on these works, which he translated into Arabic and called "The Sources of the Upper Nile."

The following lines are extracted textually from this book (p. 183):

"The opinion has already been given in these pages that any works undertaken upon the Blue Nile should be designed and carried out in the interests of the Sudan rather than of Egypt—the latter country deriving its increased discharge from the waters of the White Nile.

"There can be no question that by far the best and most certain method of increasing the Blue Nile supply, during the months prior to the annual rise, would be by the construction of regulating works at the outlet of the river from the Tsana Lake, using the latter as a storage reservoir, under effective control."

Page 172. Treating of the projects to be carried out in order to increase the summer supply in Egypt and to provide for the water necessary to the Sudan, he says:

"The best way in which to secure the results aimed at would appear to be, to reserve the waters of the Blue Nile for the improvements of the countries bordering that river, while Egypt and the area of the Nile valley lying to the North of Khartum shall derive their summer supply from the sister river."

Page 188. "Each of the projects for the Eastern Sudan, as described in the following pages, relates to Sefi or summer irrigation alone. Should it be found, upon fuller and further study, that, either on account of expense or the impossibility of increasing the Blue Nile water supply, they have to be postponed, or abandoned, there still remains the other method of adding to the productive wealth of these areas, to which the objection of an insufficient water supply does not apply. This method is the introduction of flood and winter irrigation, for the cultivation of cereals and other winter crops."

Page 190. "The best and most complete project in connection with the Blue Nile is, beyond all question, that of constructing a regulator at the outlet of the river at Lake Tsana, whereby the lake "may be converted into a storage reservoir of large size."

Briefly speaking, Sir William Garstin's statements might be summarised in the following words :—

For the reasons set forth he does not agree to the construction of a reservoir or to the erection of a dam or sudd for the storage of water in the river.

Nor does he agree to summer cultivation in the Sudan Gezira *until after the construction of Lake Tsana Reservoir.*

In the event of the increase of the Blue Nile water being impossible, any project providing for summer watering in the Sudan should be set aside, and replaced by a system of annual flood irrigation for the cultivation of cereals and winter crops.

In the Blue Book on Egypt and the Sudan for the year 1905, Lord Cromer says on page 49 :—

"Sir William Garstin's irrigation projects were based broadly on the idea that the waters of the "White Nile could be employed for the benefit of Egypt, and those of the Blue Nile for the benefit of "the Sudan."

The 1914-15 Irrigation Report (p. 49) reads as follows :—

"The damming of the White Nile, unlike the work in progress on the Blue Nile, is one of the undertakings which are to control the Upper Nile for the benefit of Egypt, the Blue Nile weir will chiefly "benefit the Sudan."

In "Nile Control," Part 6, Sir Murdoch MacDonald says :—

"Whereas Egypt can provide for its own needs from the White Nile, it is only water flowing in "the Blue Nile that can be of use to the Sudan Gezira."

He further says in "Nile Control" (p. 76) :

"The Upper Blue Nile dam need not be considered as regards Egypt, for the water it stores will "be completely utilised by the Sudan, though in the intermediate stages, before all the above works are "completed, there may be certain periods when water from this dam will be used by Egypt, if a very "low year should recur during one of the periods referred to."

In "Nile Control" (p. 14) Sir Murdoch MacDonald says :—

"The total area of the Sudan Gezira that can be commanded by the Sennar Dam is about "3,000,000 feddans."

The volume of water required for this area was estimated by Sir M. MacDonald at 18 milliards. If we bear in mind that in a year like 1913-14 the Blue Nile discharge at Sennar does not exceed 21 milliards, it will be easy to understand the reason for reserving only 3 million feddans of the Gezira lands to be irrigated by the Blue Nile, the Blue Nile supply in a year like 1913-14 being insufficient to irrigate a larger area.

In his letter to the present Minister of Public Works, dated April 20th, 1920, serving as an introduction to his last Note in English, Sir M. MacDonald says that the proposed Sudan irrigation projects are taken from the projects of Sir William Garstin, former Adviser to the Ministry of Public Works, with some modifications of order. It is to be noted, however, that he took them in a reversed order and for a purpose contrary to Sir William Garstin's intention, as the latter insisted on the construction of Tsana Reservoir before building a dam like that of Sennar.

But Sir M. MacDonald started with the Sennar Dam before providing for the Tsana Reservoir or for any other reservoir on the Upper Blue Nile, with the result that this change in order will cause Egypt, in regard to its irrigation, all the harm that Sir William Garstin endeavoured to avoid, as may be seen from his declarations to the effect that no dam should be constructed on the Blue Nile and no work of any kind should be undertaken for the Sefi irrigation in Gezira until the Lake Tsana Reservoir had been built.

The above shows clearly that it is intended to reserve gradually the whole of the Blue Nile water for the irrigation of the Sudan lands either in the Gezira or on the eastern bank, which covers an area of 5 million feddans, 3 million of which, situated in the Gezira, are said to be quite fit for cotton cultivation, as proved by experience. This is a matter the realisation of which is not impossible, seeing that perennial irrigation will be of great assistance in attaining the object in view. This is expected to occur gradually, to the great detriment of Egypt.

CRITICISM 10.

The experiments made to ascertain the ultimate water requirements of Egypt and the Sudan show that, according to the estimate of Messrs. Molesworth and Yenidunia, Egypt will require 58,000 millions (as shown in example 9). If we add 2,000 millions for navigation (p. 128), 3,000 millions, the inevitable loss to the sea during the flood (p. 15, Arabic copy of Note on Nile Control Works), and 6,000 millions required by the Sudan (p. 128), the total would be 69,000 millions, and not 56,000 millions, which is considered by the Adviser as representing the ultimate water requirements of Egypt and the Sudan after 1955 (p. 128). This is admitted on the assumption that the total area of cultivation in Egypt shall not eventually exceed 7,100,000 feddans.

CRITICISM 11.

On p. 127 it is stated that the reason for selecting Lake Albert as the most suitable site for constructing the reservoir is that it has steep sides, and therefore there will be no great increase in the area of water surface as the level rises ; consequently there will be no additional evaporation loss of any importance due to this cause. This is all very good and quite reasonable, only it remains to be proved that the lake is really as described above.

According to this the Gebel el Aulia is one of the worst sites for a reservoir, as it would increase the surface of evaporation, causing the loss of 4 milliards c.m. of water.

CRITICISM 12.

No detailed estimates have been prepared for the expenses of the projects. It has always been observed that the final cost of such works undertaken by the Ministry of Public Works attains in most cases double the amount provisionally fixed. Detailed estimates are necessary, so that, after due checking and verification, a comparison can be made between the necessary expenses and the advantage to be obtained from the projects.

CRITICISM 13.

The projects provide for the cultivation of cotton on about 3,000,000 fed. of the Sudan Gezira. Considering the amount of irrigation water required for this area as 18,000 millions, according to their estimate, the drainage water which will then pass on from this area to the White Nile will be about one-third the above-mentioned quantity.

Therefore, as a result of the proposed projects, the Nile water which flows to Egypt will consist of seepage and drainage water—a fact which should raise the greatest anxiety, as it will deeply affect the health of the inhabitants as well as the fertility of the cultivated lands. Indeed we fail to understand how the drainage water will be allowed to be used for irrigation purposes, while now it is strictly prohibited to do so, and the Irrigation Department forbids any one under pain of penalty to mix the drainage water with the irrigation water. Article 33, Canals and Banks law.

CRITICISM 14.

The allegation made by the Adviser that all the calculations of the Ministry of Public Works prior to 1912 were erroneous and that they all tended to undervalue the Nile discharge is liable to dispute. The work alluded to was undertaken by English officials and it is a matter of common knowledge among the native engineers that the high English officials of the Ministry before 1912 were very strict and exact in determining river measurements and discharges. Indeed it seems that the attention of the Adviser was only drawn to the above-mentioned errors when he wished to have the projects carried into execution.

CRITICISM 15.

The Egyptian engineers are of opinion that it is against the public weal to construct the Gebel Aulia Dam on the proposed site, where it will form a pool of stagnant water, the length of which will be about 800 kilometres, as is shown by the maps, in the neighbourhood of inhabited towns. Of course this will lead to the increase of mosquitoes and the spread of fevers. It will also overflow expensive cultivated lands, the inhabitants of which will be disturbed and obliged to seek home and bread elsewhere. In fact they will be compelled to migrate to the Gezira and work there as slaves. The mischief thus caused will be the more clearly brought to light when we remember that there is no reason to consider the site in question as the only suitable one, especially when we bear in mind that in a year like 1899-1900 or 1913-1914, when Egypt will be in sore need of every drop of water, the amount of evaporation and other losses in the Gebel Aulia Reservoir will be about 4,000 million cubic metres.

Again the expenses to be incurred in the construction of this dam are destined to be considered as a lost sum, since it is only a provisional work until the completion of Lake Albert dam. Not only this, but also the sum of L.E. 300,000 to be paid by way of compensation to the inhabitants of the flooded area. Thus the total loss will amount to L.E. 2,200,000.

CRITICISM 16.

The Adviser states that up to 1930 the maximum area to be irrigated in the Sudan is 300,000 feddans, of which not more than 100,000 of cotton will require water after 19th January. The rest will remain fallow until July 15th. On this basis, the Adviser has made his calculations (table, page 67) regarding the method of working Gebel Aulia Dam and the amount of water which will reach Egypt. The truth, however, is that the Sudan areas which will be drawing water at that time will be as follows : 300,000 feddans in the Gezira, for which the Makwar Dam is constructed at present (page 67) and of which only 100,000 will draw water from the Makwar Reservoir after January 19th, without affecting the supply of the Blue Nile in that period, which supply will entirely flow to Egypt, as they say.

The Adviser has omitted, however, the quantity of water required for the 100,000 feddans at present under cultivation in the Sudan—20,000 of which are under summer cultivation and 80,000 under winter cultivation on the basin system (page 4). This quantity should have been taken into consideration.

THE STORAGE, DRAINAGE AND SEEPAGE WATERS OF THE UPPER NILE SCHEMES AND THE HARM THEY CAN DO, EXAMINED FROM THE AGRICULTURAL POINT OF VIEW.

The question of Storage, Drainage and Seepage water is a vital one and deserves full consideration, as the harm which can be done by such waters, if the irrigation schemes are carried out, is very great.

The drainage waters of the irrigated lands of the Gezira will flow as a matter of course into the White Nile. This is due to the fact that the Blue Nile flows at a higher level than the White Nile and that the Gezira land itself slopes towards the White Nile.

This slope is 25 metres along 130 km. between Lats. 14 and 15 N. or 19 cm. per km., which is a very great slope, bearing in mind that the greatest slope in Egypt is 10 cm. per 1 km.

The level of water upstream of the Sennar Reservoir is 420.70, whereas the level of the water upstream of the Gebel el Aulia is 380.50, giving us a difference in level of about 40 metres. This great difference in level makes the water flow perpetually from the Gezira after depositing all its silt and getting rid of its natural fertility. Nay, it will carry with it a large quantity of injurious salts of various kinds.

It is clear from Sir Murdoch MacDonald's notes that the waters of the various reservoirs will be utilised for the irrigation of Egypt and the Sudan, and as the White Nile is the natural drain for the water used for irrigation in the Sudan the natural conclusion is that the water will come to Egypt deprived of its silt and completely changed from what it originally was. This is one of the greatest dangers threatening the welfare of Egypt in future.

It is reported that Sirry Pasha once said that there was no need to consider the drainage of the Gezira because, the level of the Gezira being naturally high, there was no need for any drainage system. The land of the Gezira, he says, will absorb all the surplus water. It seems that Sirry Pasha has forgotten that in course of time, and as a result of the perpetual cultivation and irrigation, land which, though generally free of salt at the surface, contains considerable quantities at a metre below the surface, will need thorough drainage. The great height of the Sennar Reservoir and the perennial irrigation of the Gezira lands will make this inevitable.

Thus it is obvious that sooner or later drains will have to be made to preserve the fertility of the land.

These drains will all flow into the White Nile, which will naturally become a general drain for them all.

To it will flow all the drainage and seepage water coming from all the agricultural lands on the White Nile, whether they are under perennial or basin irrigation, between the two levels 378.50 and 380 on both banks of the river.

In spite of the fact that Sirry Pasha says there is no need for drains, we see the alignments of these drains marked on the map of the Gezira, proving that it is the determination of the authorities to construct them. The drainage of the Gezira will be temporarily confined to the area near Wad Medani, but it will extend to 3 million feddans, the whole of whose drainage and seepage water, or one-third the irrigation water, will flow into the White Nile.

This water will indeed be detrimental to Egypt as a whole and especially to Lower Egypt, whose irrigation water will in the future be derived from that water the source of which we have explained and to which will be added the drainage water of Upper Egypt resulting from the land which has been or will be converted into perennial irrigation, amounting as a whole to two and a half million feddans.

THE EFFECT OF THE DAM FROM A HYGIENIC POINT OF VIEW.

With a view to fully investigating this point we requested Dr. Mahgoub Sabitt, B.Sc.Med., M.D. (Geneva), Diploma of Tropical Medicine (Paris), formerly Assistant Professor of Pathology and Bacteriology in the School of Medicine, Kasr el Aini, Medical Expert, Native Court of Appeal, Professor of Medical Jurisprudence and Toxicology at the Egyptian University, and he gave us the following explanations.

The great French engineer Chélu Bey *, formerly Chief Engineer in the Egyptian Sudan, and a member of the Civil Engineering Society of France, in his book "The Nile, the Sudan, and Egypt," published in Paris in 1891 (pages 19 and 25), said "that the water of the White Nile changes colour three times.

"Between March and April during a period of 20-25 days the water is green, and this is accounted for by the fact that the water comes from the marshy zone which is saturated to a great extent with vegetable matter. This water retains its green colour throughout the season, during its passage to Egypt.

"It is very injurious to health, and the inhabitants of those banks avoid drinking it while in this condition. Subsequently the green colour gives place to a new colour tinged with a reddish hue, which, however, remains only for a short time. Long before the low stage period it is changed into a semi-clear tint, sea green, i.e., light blue colour, whence it has been called White Nile." Hygienic rules establish the fact that green coloured water is unfit for drinking purposes as it contains organic matter undergoing a continuous process of conversion and decomposition.

The Sudd zone of the Nile is full of organic matter, both animal and vegetable.

From a chemical analysis of the White Nile water made on samples taken from Omdurman in March, 1877, and from Fashoda in May of the same year, that is to say, at the end of low Nil and the beginning of flood season, immediately before the rainfall in these regions, we give below the table from the book above mentioned, page 19, adding to it the analysis of the water of the Blue Nile near Khartum, page 25 of the same book, for comparison.

* Chélu Pasha, who retired from the service of the Egyptian Government ten years ago. He reprinted his book in Paris in 1910.

ANALYSIS OF NILE WATER.

NATURE OF SUBSTANCES	SAMPLES FROM THE WHITE NILE		SAMPLES FROM THE BLUE NILE	
	FROM OMDURMAN MARCH 1877	FROM FASHODA MAY 1877	FROM KHARTUM AT THE WORKSHOPS 3. 2. 1877.	FROM KHARTUM 15. 8. 1877.
(A) Substances in suspension :				
Organic substances	.5402	3.3150	.2086	2.3419
Mineral substances	.6390	.7460	1.3543	14.3922
	1.1792	1.0610	1.5629	16.7341
(B) Soluble substances per cent. :				
Lime	.1126	.1764	.5585	.6853
Magnesia	.0759	.0274	.1414	.1729
(C) Caustic Soda	.0287	.1308	.0525	.0785
Potassium Nitrate	.2174	.3645	.3007	.4070
Ammonia of Organic Substances	.0016	.0023	.0017	.0020
Sulphuric Acid	.2931	.3138	.3941	.3118
Carbonic Acid	.8228	1.4870	.4823	.5212
Nitric Acid				
(Free)	traces	traces	traces	traces
Silicates			.0832	.1433
TOTAL	1.6061	2.5022	2.0144	2.3220

This table shows that the quantity of nitrates in the form of potassium nitrate is in excess. Although it indicates complete organic fermentation and the force of ground filtrations, nevertheless it renders the water unhealthy and unfit for drinking purposes.

When organic animal substances are the source of such nitrates (*vide* page 65 of "Précis d'hygiène," by Macaigne, printed in Paris, 1911) as in the case of the White Nile, which carries numerous dead plants and animals which live in those regions and die in their waters.

It is hygienically admitted that the existence of ammonia means that the water is polluted by organic animal substances such as town drainage waters, fæces, excrements of animals, etc., and that it is sufficient for any water to contain from one to two milligrammes of ammonia per litre to render it questionable for drinking purposes (*vide* above-mentioned "Précis d'hygiène," p. 63).

In the case of the organic substances being of animal nature not more than one milligramme per litre can be allowed.

It is clear from the chemical analysis of the White Nile shown in the previous table that the Nile water at Fashoda contained 0.0023 of ammonia, while at Omdurman it contained .0016. This partial decrease of the ammonia resulting from the decomposition of organic substances is caused to some extent by the confluence of the two rivers, and it is still a large enough proportion to make the water undrinkable.

The previous table in connection with the White Nile shows the existence of carbonic acid in excess in the White Nile caused by the decomposition of vegetable substances obstructing the bed of the Nile, and by the decomposition also of enormous numbers of animals which live and die in this huge basin, that is, the Sudd zone at the 9th degree of latitude. Mr. Chélu says in his above-mentioned book (page 15):

"The water of the White Nile in this zone and the rest of its course up to Khartum loses its clearness and becomes charged with a bad smell by reason of its being heavily saturated with the organic matters decomposed therein and is never good for drinking. It is nothing but 'purgative water' which flows from those regions carrying microbes and parasites of infectious diseases which can only live in water saturated with decomposed organic matter, such as the microbes of malaria, which is brought about by mosquitoes that exist in abundance in those districts, dysentery, poisonous flies, different species of aqueous worms, such as Bilharzia and Filaria Medinensis, other kinds of Filaria worms and microbes which cause what is called 'Nile sores' and other fatal diseases resulting from microbes germinated in those regions, such as the sleeping disease and the black-water fever."

During the month of October, about the end of the rainy season, the vegetable matter exposed to the sun undergoes fermentation and decomposition. The air of that zone in fact becomes saturated with the malaria and other injurious and even deadly microbes. This was noticed by Mr. Chélu and other investigators during their researches in those districts.

The water reaches its worst condition during the period between March and April. What would become of Egypt should it be deprived of the water of the Blue Nile, that pure and clean water, with its rich, fertile and precious silt, that water which surpasses in purity that of the slowly running White Nile, whose water is mixed with the residues of impure organic matter? If Egypt is deprived of the water of the Blue Nile, its drinking water will be nothing but stagnant and poisonous water, the water of the Sudd zone, water which is even refused by tribes living for centuries on the banks of the river and

which is kept in the marshy region at Lat. 9.* If we add to this the fact that the water of the White Nile, after being stored for a year in the Albert Nyanza Lake and stopped in the swamps at Lat. 9, *i.e.*, the Sudd zone, and after depositing whatever silty matter is brought to it by the river Sobat, leaves this zone and enters the White Nile proper which has only a very slight slope, it does not continue long in this slow course, but after a short course it enters the Gebel el Aulia Reservoir, whose length is 800 km. and width 25 km., that is to say, a huge lake where the water is being stored from previous years covered with layers of all kinds of living organisms and mosquitoes which carry the microbe of malaria and all kinds of Filaria and other microbes of fevers. It is not possible to understand how to fight these huge swarms of mosquitoes, and how much petrol would be required to cover the surface of this huge lake whose area is about 1,500,000 feddans (6,400 square kilo), this being the surest way of destruction, and what finance can stand this huge expense? †

It must be remembered that at Aswan, it is the top two or three layers, especially the uppermost layer, which becomes green and offensive and unwholesome. The lower water is much less affected. As the Aswan Reservoir is narrow and deep, it results that only a small part of the water of the reservoir is very bad. In a broad shallow lake like the proposed Gebel Aulia Reservoir, the greater part of the water will be very bad and unwholesome.

It is for this reason, moreover, that the deepening of the water in the Aswan Reservoir by increasing the height of the dam will not only not increase proportionally the bad quality of the stored water, poor in oxygen, but will decrease it.

It is difficult to conceive what has been stated in the Arabic translation of the report of the London Committee appointed in 1919 to investigate the Nile Projects, that although it is undeniable that if the water of the ponds were left stagnant there would be an increase of mosquitoes, still it would be possible to prevent this by taking the necessary measures, bearing in mind that the nearest point of the reservoir will be about 25 miles from Khartum.

We can see no surer measures but those we have already mentioned for the destruction of those mosquitoes. Moreover, have not the measures which were taken since the conquest of the Sudan in 1898 proved to be futile? It is a fact that the prevalence of malarial fever in all its different forms, acute and otherwise, is not confined to the Sudd regions, the swamps of Bahr el Gazal and Sobat only, but comprises many parts of the Sudan, as can be shown by the continuous complaints coming from those living there, whether Sudanese or Egyptian Officials.

Many lives were victims of the deadly fevers. The only cause of all the trouble is the existence of those swamps formed by the branches of the White Nile and those lakes which are natural reservoirs. The reservoirs proposed in the Nile Projects are nothing but artificial lakes intended to store water. It would be impossible to discharge all the water from some of them every year, and consequently water would remain there stagnant for years. It is inconceivable how the Committee of London appointed in 1918 for the investigation of the Nile Projects could depend on a single opinion given in 1911 by Dr. Andrew Balfour, formerly director of the Sudan Health Department, taking his opinion as that of an indisputable authority on questions of this nature, and asserting that "he does not expect any particular danger to threaten public health as a result of building that reservoir" (page 9, Nile Projects, line 48, Arabic Trans.), while in the English copy Dr. Balfour is quoted to have said: "So far as Khartum is concerned I cannot see that health conditions are likely to be affected by such a scheme" (page 75). In spite of the two different meanings conveyed by the two sentences Dr. Balfour confined his opinion, given with reserve, to Khartum. We believe that he based his opinion on the sanitary measures at Khartum expecting from them more than they are really capable of.

His opinion about the sanitary conditions of the regions of that reservoir, or rather of that vast lake, swarming with dense layers of mosquitoes and bad water, is, however, contrary to that of Dr. Chambers, his successor at the Wellcome Research Laboratories and the Sudan Health Department, given when the Nile was high in 1918, and remained so for a long time covering those areas resembling the proposed reservoir of Gebel el Aulia when the Nile is at its lowest stage.

It is also noticed that Dr. Balfour expressed his reserved view on April 10th, 1911, at a time when the Nile did not cover more than one-sixth of the area to be covered with water when the reservoir is full (*vide* page 55 of the Nile Control).

In addition to this he did not give his opinion on the harmful effects of these projects, from the sanitary point of view, on those who would drink only from the White Nile, whether Sudanese or Egyptians, and who would be deprived of the Blue Nile and its red Abyssinian waters, and also would have in their main river nothing but dirty and infected water coming from the filtration and drainage of the Gezira—such as would only make that of the White Nile greatly dangerous to health and poorly fit for cultivation.

Not contented by the opinion of Dr. Balfour, the Adviser of the Public Works Department went further to say that at the time the Aswan Reservoir was made, similar fears were expressed as to its possible bad effect on sanitation, and there is every reason to believe that the fears about the White Nile dam are as groundless as those about the Aswan Dam.

* It is well known that the inhabitants of Omdurman drink Blue Nile water although they are nearer to the White Nile, and that other localities situated on the same river drink from wells. It is also known that the Taashi, the Caliph, and the Mahdi used to punish offenders by committing them to drink White Nile water.

† See page 16, line 32, of Sir Murdoch MacDonald's Report, in which he says, "and this quantity cannot be obtained except from previously stored water." And see lines 15, 16, and 17, "It is evident that the quantity of water required cannot be obtained from the future flood but from stored up water of a previous flood." See also Lecture of the Minister of Public Works, page 7, lines 5 and 6.

But we draw the attention of the Adviser to the fact that the sanitary conditions in Egypt have become worse since the erection of the Aswan Dam, as can be ascertained from the reports of the Public Health Department which appeared after its completion, especially in summer, when the Nile is at its lowest stage.

Many diseases made their appearance among the people, the animals and plants of the country.

Malarial fever showed persistent tendency to increase and in spite of all measures the Public Health Department is unable to expel it even from towns like Helouan, and other localities in Egypt and the Sudan. Typhus has become recently of a plague character even more rampant than it was at Galicia, where its spreading was more than ever known to Europe during the great European War. Cases of typhoid of more acute form have become more frequent than ever known in this country. Septicemia, hemorrhagia, cattle plague, cotton worm, clover worm, and other diseases attacking human, animal and plant life are manifest.

Had Sir M. MacDonald paid attention to the sanitary reports issued in summer, that is, at the time when the Nile is at its lowest stage and nothing is stored up in the upper regions, he would have seen that the number of deaths is one and a half times as much as that of births. The only cause is the spreading of different diseases during the low Nile period when most of the water taken for drinking and irrigation is taken from the Aswan Reservoir.

It must be noticed also that then the number of deaths in Egypt surmounts the number of births. In Cairo, for example, according to the report of the Public Health Department, the number of births during the week ending May the 13th, 1920, was 677 and that of deaths 751, that is, with a difference of 74 in a single week. What would be the number of deaths during whole months when the river is at its lowest height? It must also be noticed that 272 of the deaths were caused by different kinds of fever and that this number does not include those many cases which were not reported to the Public Health Department. Are those facts unworthy of serious consideration? It is very clear also that conditions grow better when the flood is high and what good effects it produces on man, animal and plant.

Assuming that the Adviser has examined the subject from the technical and engineering point of view, and that the criticisms in connection with the projects from that point are left to my technical colleagues, we cannot conceal our astonishment to see him giving a medical decision upon the sanitary conditions that would result from the carrying out of the Nile Projects without very closely and scientifically examining them. It was imperative to appoint a mixed medical committee to examine the water of both the White and Blue Niles and to publish the results of their chemical, biological, and bacteriological analyses so as to give a correct opinion about the exact qualities of the water and its effects on the health of man, animal, and plant. To carry out these Nile Projects without thoroughly and scientifically examining them from all technical points of view by means of technical committees is to expose this country to dangers which would threaten not only its people but also its plants and animals. Is it right, in the twentieth century, with its civilization and scientific progress, that such important schemes, like the present reservoir projects, which would discharge the water of the low Nile period, that is, the water stored for a year or more as we have already shown, to be used for irrigation and drinking purposes, could be carried out without scientific investigation by experts in pathology and hygiene associated with agriculturists, chemists and sanitary engineers and bacteriologists?

Is it right to give a decisive judgment based on an opinion given with reserve from a single specialist, Lieut.-Col. Dr. Andrew Balfour, on such a vital question, and that in 1911?

No doubt that the aphorism of Herodotus, the famous Greek historian, that Egypt is the land of wonders and contradictions still holds good for what is going on in the land of the Pharaohs.

We repeat and remind the world that the Egyptian question is the question of the Nile, for the existence and life of Egypt depend not on a part of the Nile but on the Nile as a whole.

Speaking in the interests of both Egypt and the Sudan, we conclude by insisting that whatever water is stored for the material development of both countries be stored in the existing natural reservoirs, whether they be in the Lake Albert region or the Sudd region. In these localities the worst that can be done is already done, and the increasing of the depth of the water without increasing its surface, which will accompany the provision of extra storage, will go toward making the water less impure and not more impure.

We condemn, in the strongest terms we are capable of using, the creation of a new unhealthy region of shallow marsh and swamp, which will lose by evaporation 4 milliards of cubic metres of the 8 milliards stored on it, and which will breed disease and pollute water over an area inhabited to-day by 100,000 agriculturists and herdsmen, an area capable of great development, and one of the healthiest tracts in the whole Sudan.

We consider it inhuman to drive 100,000 people from their healthy homes, and at the same time bring the dangers and diseases of the Sudd region within 50 kilometres of Khartum.

I refer the Commission to paras. 22, 23, 24, 33, 35 and 41 of Sir John Rogers' Report on "The Sanitary Aspect of Nile Reservoir," 1894. Rogers Pasha was Director-General of the Sanitary Department of Egypt.

CONCLUSION.

By submitting this Note it is not our intention to stand as a stumbling block in the way of the proposed projects nor of any other engineering works which may tend to increase the supply of the Nile or prevent the loss of a single drop of its waters. Our sole object is to make clear the injuries that are sure to befall both Egypt and the Sudan in case the projects are executed in their present form.

(Signed) ABDULLAH PASHA WAHBI.
MOUSSA PASHA GHALIB.
ABDEL KAWI AHMED.

IBRAHIM ZAKY.
MOHAMED ISMAIL BEY.

